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Szabványtár

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OPERATING MANUAL

1950 HP NOHAB-GM
DIESEL-ELECTRIC LOCOMOTIVE

GENERAL PURPOSE

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SECTION 1

GENERAL DESCRIPTION

NOHAB-GM diesel locomotive, Fig. 1-1, described in this operating manual is actually a dieselelectric locomotive, utilizing electrical equipment to transmit the power developed by the diesel engine to the locomotive driving wheels. The only purpose of the diesel engine is to rotate the main generator and air compressor to produce electricity and compressed air. The electricity produced by the main generator is conducted through wires and suitable switchgear to electric traction motors and blowers.

Three traction motors are mounted in each truck. The traction motors are geared to separate axles and thereby cause the locomotive driving wheels to turn when power is applied. Electricity is generated and used only as needed. The diesel engine runs at idle speed when power is not needed to drive the wheels, and engine speeds and power are under the control of the driver or operator at all times.

In this manual the word "engine, will designate the diesel engine. The word "locomotive" will refer to one or more locomotive units coupled together to operate as one locomotive.

HOW A DIESELELECTRIC LOCOMOTIVE WORKS

1. The fuel pump is driven by an electric motor using current from the storage battery. It transfers fuel from the tank under the locomotive through filters to the engine injectors.
2. The diesel engine is started by means of the direct coupled main generator which is temporarily used as a starting motor. The storage battery supplies the electric current to rotate the generator and start the engine.
3. When the engine is running, it supplies mechanical power through shafts and couplings to directly drive two electrical generators and the air compressor.
4. The main generator supplies high voltage electricity to the traction motors for locomotive pulling power and alternating current to drive the engine water coolings fans and traction motor blowers. The auxiliary generator charges the storage batteries and supplies low voltage current for control, lighting, main generator battery field excitation, fuel pump and steam generator operation.
5. By means of the cab controls, low voltage circuits are established to actuate the various contactors, switches, and relays in the electrical cabinet as well as the engine governor.

6. Six traction motors are under the locomotive, each of which is directly geared to an axle and a pair of driving wheels. These motors are located in two trucks which support and distribute the locomotive weight on the driving wheels.
7. The throttle electrically actuates a governor mounted on the engine and controls engine speed and power. Through the main generator the engine's mechanical power, which is then distributed to the traction motors through circuits established by various switchgear in the electrical cabinet.
8. A load regulator is used to prevent the engine from being over or underloaded and thus provide power uniformly in accordance with each throttle position.
9. The air compressor supplies air pressure to the reservoirs which is then used primarily for the air brakes, which are controlled by the driver through suitable equipment in the cab.
10. Other than manual operation of the cab controls, the locomotive operation is completely automatic. Various alarms and safety devices will alert the driver should any difficulty occur.

GENERAL DATA

Gross Horsepower Rating	1950
Test Horsepower Rating	2200
Engine Model	16-567D1
Number of cylinders	16
Engine type	"V" 45° Between banks
Bore	8.5" - 216 mm
Stroke	10" - 254 mm
Compression ratio	20:1
Total displacement	9072 cu.in. - 148.8 liters
Maximum speed	835 RPM
Idle speed	275 RPM
Main Generator Model	D22A-D14
Nominal Voltage	600 volts DC
AC Rating at 0.8 power factor	100 kVA
Auxiliary Generator Rating	18 KW
Operating Voltage	74 volts DC
Storage Battery Rating	284 ampere hours
Voltage	64 volts DC

WEIGHTS

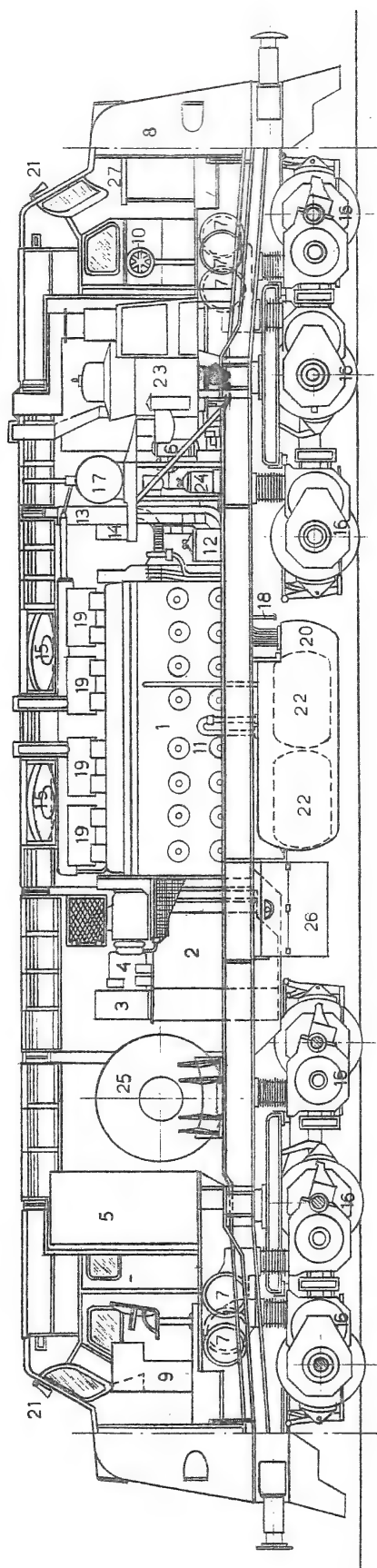
Weight - Fully Loaded	108.660 kg
Weight in running order	
(with 2/3 or running supplies)	106.130 kg
Weight without supplies	101.100 kg
Maximum axle load	18.110 kg

SUPPLIES

Lubricating oil	760 liters	
Fuel Oil	3000 liters	
Cooling Water	870 liters	
Water for steam generator	3000 liters	
Sand	300 liters	525 kg.

DIMENSIONS

Total wheel base	14300 mm
Distance, end of hood to centerline of bolster	3700 mm
Distance between bolster centers	10300 mm
Distance over buffers	18900 mm
Truck wheel base	4000 mm
Width over handholds	3090 mm
Overall height	4295 mm
Diameter of wheels	1040 mm
Roller bearing journals	152 mm x 279 mm
Minimum curve radius	90 m
Track gauge	1435 mm



- | | |
|-------------------------------|-------------------------|
| 1. 16-567 D1 Engine | 19. Exhaust Manifold |
| 2. Main Generator | 20. Fuel Tank |
| 3. Generator Blower | 21. Horn |
| 4. Auxiliary Generator | 22. Main Air Reservoirs |
| 5. Electrical Control Cabinet | 23. Steam Generator |
| 6. Compressor | 24. Fuel Oil Filter |
| 7. Traction Motor Blower | 25. Water Tank |
| 8. Air Brake Equipment Rack | 26. Battery Box |
| 9. Driver's Control Stand | 27. Hot Plate |

General Arrangement

SECTION 2

OPERATION

The operating controls can be seen in Fig. 2-1. The driver's controls consist of four levers: the throttle, and reverse levers located in the driver's control stand, and the automatic and independent brake levers.

200. REVERSE LEVER

The reverse lever, Fig. 2-2, has three positions: FORWARD, NEUTRAL and REVERSE.

The movement of this lever to FORWARD or REVERSE controls the direction in which the locomotive moves.

With the reverse lever in NEUTRAL no power will be developed, even though the engine speed may be increased. See Article 224, Coupling To Train and Pumping Up Air.

The reverse lever should be moved ONLY when the locomotive is standing still.

The reverse lever can be removed from the control stand only when it is in NEUTRAL (centered) the throttle is in IDLE. Removal of the reverse lever locks the operating controls.

Remove the reverse lever from the control stand of all nonoperating units in the locomotive consist.

201. THROTTLE LEVER

The speed of the diesel engine in normal operating is controlled by the throttle lever, Fig. 2-3, or the hand wheel on the top of the control stand.

The position of the throttle is shown in the illuminated indicator above the throttle lever. The throttle has ten positions: STOP, IDLE and Running Speeds 1 to 8 inclusive. STOP is obtained by pulling the lever away from the stand and then moving it past IDLE position to the limit of its travel. This will stop the engines in all locomotives of the consist. IDLE position is the limit of throttle lever travel without pulling the lever away from the control stand. Running Speed 1 is the same engine speed as IDLE and is used to set up certain electrical circuits.

The remaining seven positions, Run 2 through Run 8 will increase the engine speed in 80 RPM increments until the maximum speed of 835 RPM is reached.

The throttle may be closed completely in one motion in an emergency, but in normal operation should be closed one "notch" at a time. It may be opened as rapidly as desired consistent with operating conditions and train consist.

This arrangement is of special value in shunting cars and while operating over the road on "close" schedules.

202 MECHANICAL INTERLOCKS ON THE CONTROLLER

The levers on the control stand are interlocked so that:

1. The reverse lever can be operated only with the throttle at IDLE.
2. The reverse lever can be removed from the control stand only with the throttle in IDLE. Removing the reverse lever locks the throttle.
3. The throttle lever can be moved to STOP with reverse lever in any position.
4. The throttle lever in STOP locks against movement of the reverse lever.

203. OPERATING SWITCHES

The driver's control panel is shown in Fig. 2-4.

On this panel are placed switches for light, governor, control, generator field and automatic sanding.

In the Electrical Cabinet there are circuit breakers for control, fuel pump, power contactors and light, Fig. 2-5. The isolation switch and stop and start push buttons are placed in the engine room. To start the diesel engine and control its speed from the throttle, the Control and Fuel Pump and Governor switches must be ON. To move the locomotive, the Generator Field Switch must be ON, and the Isolation switch in RUN. The automatic sanding feature is cut in with the Automatic Sanding switch in the ON position.

204. INDICATING LIGHTS

Located on the driver's control panel are the indicating lights, Fig. 2-4.

These are: Hot Engine Alarm, Wheel Sleep, Steam Boiler stopped, Blow down Steam Generator, Pneumatic Control Switch Open, Alternator failure (No AC Power), and Ground Relay.

205. AIR BRAKE GAUGES

The gauges are shown in Fig. 2-4. The function of each gauge is clearly identified.

206. AUTOMATIC BRAKE VALVE KNORR TYPE D2

The automatic brake valve handle is self lapping and has six positions: Filling position, running position, intermediate position, brake position, full brake position and emergency brake. In multiple unit operation the automatic brake handle in the trailing units should be in the intermediate position.

207. INDEPENDENT BRAKE VALVE KNORR TYPE Zb1

The independent brake valve is also of the self lapping type. Between the two extremes of release and full application the movement of the handle in its sector will give a proportionate increase or decrease in brake cylinder pressure.

If the locomotive is trailing in multiple unit operation, the independent brake valve handle should be in the release position.

208. SAFETY CONTROL FOOT PEDAL

The safety control foot pedal is located below the driver's control panel on the floor. The pedal must be kept in operating position at all times except when the locomotive is stopped and the reverse lever is in neutral position.

The Safety Control Foot Pedal has three positions: Top position which releases emergency brake, intermediate position for running and bottom position which also releases emergency brake.

209. ENGINE CONTROL PANEL

The engine control panel, Fig. 2-6, is located in the engine room near the manual layshaft lever. It contains the engine STOP and START push buttons, and the isolation switch.

210. ISOLATION SWITCH

This switch has two positions: START (handle vertical) and RUN (handle horizontal). In START position the power plant is isolated (off the line) from the control circuit and the engine speed is reduced to idle. The engine will remain at idle speed and will not respond to throttle control. The power contactors in the electrical cabinet will not close when the control levers are moved.

The engine START and STOP buttons are effective only with the isolation switch in the START position.

The isolation switch must be in the RUN position for the unit to develop power.

211. ENGINE START AND STOP BUTTONS

The engine START and STOP buttons, which are located on the engine control panel, are operative only with the isolation switch in the START position. When starting the diesel engine, press START button in firmly and hold until engine starts, but not for more than 15 seconds. To stop engine, press STOP button in firmly and hold in until engine stops. This involves no time limit but the isolation switch must be in the START position.

212. CIRCUIT BREAKERS

Located on the distribution panel in the electrical cabinet, Fig. 2-5c, are the following circuit breakers:

- | | |
|-------------------|---------------------|
| 1. Control (pos.) | 3. Power contactors |
| 2. Fuel pump | 4. Inside light |

213. BATTERY CHARGING AMMETER

The battery charging ammeter shown in Fig. 2-5 c, shows the rate of charge or discharge of the locomotive battery. When the diesel engine is running it should read zero or show slight amount of charge.

214. FUSES AND KNIFE SWITCHES

Fig. 2-5 c shows the following fuses and knife switches:

1. 80-ampere battery field fuse
2. 30-ampere auxiliary generator field fuse
3. 60-ampere AC Generator field
4. 30-ampere control fuse, negative
5. 250-ampere auxiliary generator fuse
6. 400-ampere starting fuse
7. 2 st. 6-ampere measuring terminal generator voltage fuse
8. 6-ampere voltmeter fuse
9. 15-ampere hot plate fuse
10. Battery knife switch

215. MEASURING TERMINALS

Located on the distribution panel Fig. 2-5 c, are the following measuring terminals:

1. Generator voltage
2. Shunt Field current
3. Battery Field current

INSPECTIONS

The successful operation of a locomotive is dependent not only on the regular inspections performed by the maintenance personnel, but also on the proficiency of the operation crew. The following inspections should be made in preparation for service.

216. WHEN BOARDING THE LOCOMOTIVE

A. Ground Inspection - Locomotive Exterior And Running Gear

Check for:

1. Fuel oil, lube oil, water or air leaking from the locomotive piping systems or tanks.
2. Loose or dragging parts.
3. Proper positioning of angle cocks and shut-off valves.
4. Observe brake cylinder piston travel, if air brakes are set.
5. Check the condition of brake shoes.
6. Drain condensate from the main reservoirs.
7. See that an adequate fuel supply is showing in fuel tank.
8. Check for proper connection of air hoses and jumper cable (if to be used in multiple unit operation).

B. Engine Room Inspection

(If the diesel engine is stopped, see Arts. 219 and 220 for starting instructions.).

With the diesel engine running, check the following:

1. Lubricating oil supply
 - a. Diesel engine.
 - b. Governor.
2. Diesel engine lube oil pressure gauge.
3. Fuel flow in fuel return sight glass.
4. Check for oil, water or fuel leaks.
5. Engine cooling water level in supply tank.
6. Close air box drain valves.

217. AIR BOX DRAINS

The engine air box accumulation settles in two drain tanks incorporated in the engine oil pan near the generator end, one on each side. Two air box drain valves, Fig. 2-7, permit draining of these tanks. The tanks should be drained periodically when the locomotive is standing. With the air box drain valves open, observe the drain pipe discharge under the locomotive to determine if there is any water or an excessive oil accumulation in the air box. If a discharge is observed from the drain pipes with the air box drain valves closed (accumulation flowing through overflow pipe), the reason for air box accumulation should be investigated by a competent engine mechanic or supervisor.

218. OPERATING CAB INSPECTION

Check the following:

1. The control switch as well as the control and fuel pump circuit breakers should be ON.
2. Place the throttle lever in IDLE, the reverse lever in NEUTRAL.
3. Check position of automatic and independent brake valves. Automatic should be in RELEASE position. Apply independent brake.
4. In the electrical cabinet all fuses must be securely in place, all knife switches closed and circuit breakers should be ON.
5. The battery charging ammeter should read zero or a slight charge (if engine is running)
6. The isolation switch should be in RUN.

219. PRECAUTIONS BEFORE STARTING ENGINE

The following list of items should be performed when an engine is to be started after a layover.

1. With the locomotive stopped, place the independent brake valve in FULL APPLICATION position.
2. Check the position of all valves and drains in cooling system, lube oil system, and air reservoirs.
3. Check engine cooling water level.
4. Check lube oil supply.
 - a. In diesel engine.
 - b. In engine governor.
 - c. In air compressor.
5. Place the isolation switch in START position.
6. At the electrical cabinet: all fuses must be in place, all knife switches closed, and the circuit breakers should be in the ON position.
7. Reverse lever must be centered.
8. At the driver's control station, place the control switches in the ON position.
9. Check the Pneumatic Control switch light - it should be off.
10. Check to see that all cylinder test valves, Fig. 2-8, are closed. If found open or loose they may be tightened by means of the special wrench shown. Cylinder test valves must never be allowed to loosen or come open during engine operation.

220. TO START ENGINE

After completing the items mentioned in Art. 219 the engine may be started by performing the following steps:

1. Check for fuel flow through return fuel sight glass on fuel filter mounted on the front of engine, Fig. 2-9.
2. Check position of engine overspeed trip reset lever.
3. Check position of governor low oil trip button.
4. With the isolation switch in the START position, firmly press IN the engine START button, Fig. 2-6, and hold it in until engine completely starts (not over 15 seconds).
5. After the engine is started, check lube oil pressure.
6. Check for ground relay action.
7. Do not work the engine until temperature becomes normal. (min. 50° C)

221. PRECAUTIONS BEFORE MOVING LOCOMOTIVE

1. NEVER move a locomotive, under its own power, without having first observed proper application and release of the brake shoes.
2. Check the main reservoir air pressure.
3. Release the hand brakes and remove any blocking of the wheels.
4. Engine cooling water temperature should be as specified, i. e. min. 50°C.

222. PLACING AN ENGINE ON THE LINE

Before the driver can control the speed of the engine with the throttle lever, the engine must be placed "on-the-line", and the governor switch must be in the ON position.

After the oil pressure has built up, the engine may be placed on-the-line by merely placing the isolation switch in the RUN position, Fig. 2-6.

223. HANDLING LIGHT LOCOMOTIVE

With the engines placed on-the-line and cab preparations completed, the locomotive is handled as follows:

1. Move generator field switch to ON.
2. Insert and move the reverse lever to the desired position. (This lever is to be moved ONLY when the locomotive is standing still).
3. Depress the safety control foot pedal.
4. Release the air brakes.
5. When running light, open the throttle a notch at a time. When kicking cars, etc., the throttle may be advanced as far and as rapidly as needed.

224. COUPLING TO TRAIN AND PUMPING AIR

After coupling to a train, stretch the coupling to make sure it is properly connected. If main reservoir pressure falls below feed valve setting when brakes are cut in, proceed as follows:

1. Place generator field switch in OFF position.
2. Place reverse lever in NEUTRAL.
3. Open throttle to 4th, 5th or 6th notch, as needed, to replenish the compressed air supply.
4. Place selector valve or air brake equipment rack in G or P depending on what kind of train is to be hauled.
5. Position automatic Brake Valve in proper position.

225. STARTING A TRAIN

Starting a train depends on the type, length weight of train, grade, weather conditions and the amount of slack in the train. Because of the locomotive's very HIGH STARTING TRACTIVE EFFORT it is important that the train brakes be COMPLETELY released before attempting to start the train.

The NOHAB-GM locomotive is designed to have a COMPARATIVELY RAPID YET SMOOTH BUILD-UP OF POWER.

When ready to start, the following general procedure is recommended:

1. Move the reverse lever to select the desired directional movement.
2. Depress the safety control foot pedal and release the air brakes.
3. Open the throttle to No. 1 or 2 position, pausing one to two seconds between each notch.

At an easy starting place, the locomotive may start the train. If the train does not start in No. 1 or 2 advance to No. 3 or higher until the locomotive moves. Experience and the demands of the schedule will determine the best method of starting a train.
4. Reduce throttle one or more notches if acceleration is too rapid.
5. After the train is stretched, advance the throttle as desired to accelerate.

NOTE:

If the wheel slip indicator flashes continuously, reduce the throttle one notch. Apply sand as needed to prevent further slipping (or place auto-sanding switch ON) and reopen the throttle when rail conditions improve. See Art. 230 Automatic Sanding In Power.

Although it will generally be unnecessary to take slack in starting, there will be cases where it is wise to do so, after making sure that all brakes are released on the train. The throttle should be opened one notch at a time in starting the train. A TONNAGE TRAIN SHOULD BE STARTED IN AS LOW A THROTTLE POSITION AS POSSIBLE, BEARING IN MIND THAT THE SPEED OF THE LOCOMOTIVE MUST BE KEPT AT A MINIMUM UNTIL

THE TRAIN HAS BEEN STRETCHED. Sometimes it is advisable to reduce the throttle a notch or two the moment the locomotive begins to move, in order to prevent stretching the slack too quickly. The driver must be the judge of the rate of acceleration and the conditions under which the train is being started.

When the locomotive has moved far enough to stretch the train completely, the throttle may be further advanced. Smooth acceleration is obtained by opening the throttle one notch at a time, but not so quickly that slipping results.

226. ACCELERATION OF A TRAIN

When the throttle is in the 8th notch and the train begins to accelerate, transition will automatically take place without any attention on the part of the driver, other than necessary throttle reductions to keep within speed restrictions.

227. MAXIMUM SPEED LIMITATION

The Maximum locomotive speed is determined by the maximum permissible safe rotational speed of the traction motor armatures. Thus, the maximum permissible speed limit is depend upon gear ratios.

Gear ratio are expressed as a double number, the smaller being the number of teeth on the traction motor pinion gear, the larger representing the amount of teeth on the axle gear.

The maximum safe speed limits according to gear ratio.

Gear Ratio	Max. Permissible Speed Limit
62/15	65 MPH - 105 KMH

228. OPERATION OVER RAILROAD CROSSINGS

When passing over railroad crossings, reduce the throttle to at least the 5th notch before reaching crossing and leave reduced until all power trucks are over the crossing. This will reduce the arcing between the brushes and traction motor commutators.

229. WHEEL SLIP INDICATION

The wheel slip light will flash on immediately when a pair of wheels has slipped. The detection of wheel slip action automatically reduces the power application to stop the slipping. Normal power will be reapplied automatically after slipping has stopped.

It will generally be unnecessary to reduce the throttle because of a momentary wheel slip action. Sand may be applied to prevent repeated wheel slipping which may occur with extremely poor rail conditions.

230. AUTOMATIC SANDING IN POWER

The locomotive are equipped with automatic sanding in power to assist in controlling wheel creep and wheel slip. Rail sanding automatically takes effect when the wheel slip relay picks up and main generator output is momentarily reduced. At wheel creep the main generator output is not reduced.

The duration of sanding time following the wheel slip, is controlled by a time delay sanding relay (TDS). An off-on switch on the driver's control panel may be used to cut in or out this sanding-in-power feature.

With the auto-sanding switch in ON position, manual throttle reduction to avoid repeated wheel slip will rarely be necessary. The manual operation of sanders by the driver at points on the road where slippage is likely to occur can be eliminated.

231. BRAKE OPERATION

The method of handling the brake equipment is left to the discretion of the individual railroad. However, when braking with power applied, it must be remembered that for any given throttle position the drawbar pull rapidly increases as the train speed decreases. This pull might become great enough to part the train unless the throttle is reduced as the train speed decreases. The throttle MUST be in IDLE before locomotive brakes are applied.

232. SECURING LOCOMOTIVE FOR LAYOVER

1. Place the reverse lever in NEUTRAL position, and throttle in IDLE.
2. Remove the reverse lever from controller.
3. Place isolation switch in START and press STOP button IN until engine stops.
4. Place all switches at the driver's control panel in OFF position (down).
5. Open the battery knife switch and circuit breakers in the electrical cabinet.
6. Apply hand brake and block the wheels, if necessary.
7. Cover the exhaust stacks, if there is danger of a severe rain or if locomotive is to be exposed to weather.
8. Take the proper precautions against freezing of the cooling water system in cold weather.

233. TO STOP ENGINE

There are three ways of stopping engines: these may be designated as (1) normal, (2) under power, and (3) emergency.

1. Normal stopping of an engine applies when the locomotive is standing, or parked. In this case place the isolation switch in the START position and press in on the STOP button. Fig. 2-6.

2. Under power, or whenever necessary, and engine can be taken "off the line" by pulling the engine manual layshaft closed until the engine stops, Fig. 2-8. After stopping the engine place the isolation switch in the START position.
- 3 In an emergency when two or more locomotives are coupled together for a multiple unit operation, all engines may be stopped simultaneously by reducing the throttle to IDLE then pulling the lever out away from the controller and moving it one step beyond IDLE to the STOP position as shown in Fig. 2-3. All isolation switches should then be moved to the START position to silence the alarm bells. This procedure also applies to single unit operation.

234. FREEZING WEATHER PRECAUTIONS

In freezing weather, extra precautions must be taken to see that water in the locomotive does not freeze when the engine is shut down for any reason.

In freezing weather if heating facilities are not available, all water must be drained from:

1. Engine cooling system. Also, remove pipe plug from bottom of right water pump housing.
2. Air system (condensation accumulations).
 - a. Air compressor oil separator
 - b. Sump reservoir
 - c. Main reservoirs
 - d. Cabradiators
 - e. Air compressor intercooler
 - f. Air strainers.

MISCELLANEOUS OPERATING INSTRUCTIONS

235. HANDLING LOCOMOTIVE DEAD-IN-TRAIN

1. Air brake equipment
 - a. Place the independent and automatic brake valve handles in the Release and Neutral positions, respectively.
In the brake equipment rack the selector valve is placed in the CUT OUT position.

The locomotive will now operate like that of a car in the train.

2. Electrical control quipment
 - a. Remove the reverse lever from the controller.
 - b. Place the isolation switch in the START position.
 - c. All switches should be in position OFF.

If it is necessary to keep the engine idling while hauling locomotive, the control local control and fuel pump circuit breakers, and control and fuel pump switch must be ON.

236. DOUBLEHEADING

Prior to doubleheading behind another locomotive, make a full service brake pipe reduction with the automatic brake valve. Return the automatic brake valve handle to the neutral position and place the independent brake valve in release position. The operation of the throttle is normal, but the brakes are controlled from the lead locomotive. The driver on the second locomotive may make an emergency application of the brakes with automatic brake valve, and/or may release his locomotive brakes by moving the independent brake valve handle in the Release position.

237. RUNNING THROUGH WATER

Under ABSOLUTELY NO circumstances should the locomotive pass through water which is deep enough to touch the bottom of the traction motor frames. When passing through water, always go at a very slow speed (2 or 3 MPH - 3-5 KMH). Water any deeper than 3" above the top of the rails is likely to cause damage to the traction motors and should be avoided.

238. MULTIPLE UNIT OPERATION

In operating the locomotive in multiple with each other, the operating controls of the lead unit are set up as outlined in Art. 218, the trailing unit in Art. 241. When set up for multiple unit operation, the following precaution should be observed.

239. UNCOUPLING AND COUPLING LOCOMOTIVES IN MULTIPLE UNIT

1. To uncouple locomotives.
 - a. Apply brake and close the "Ackerman valves" units on all air hoses.
 - b. Take down all power plant jumper cables.
 - c. Break hoses and separate units by uncoupling.
2. Coupling locomotives.
 - a. Couple and stretch units to ensure that the couplers are locked.
 - b. Connect hoses and jumpers, and be sure all necessary valves are opened.
 - c. In any nonoperating cab, cut out the brakes and place all switches in OFF position. Remove the reverse lever from the controller in all trailing units.

240. CHANGING OPERATING ENDS

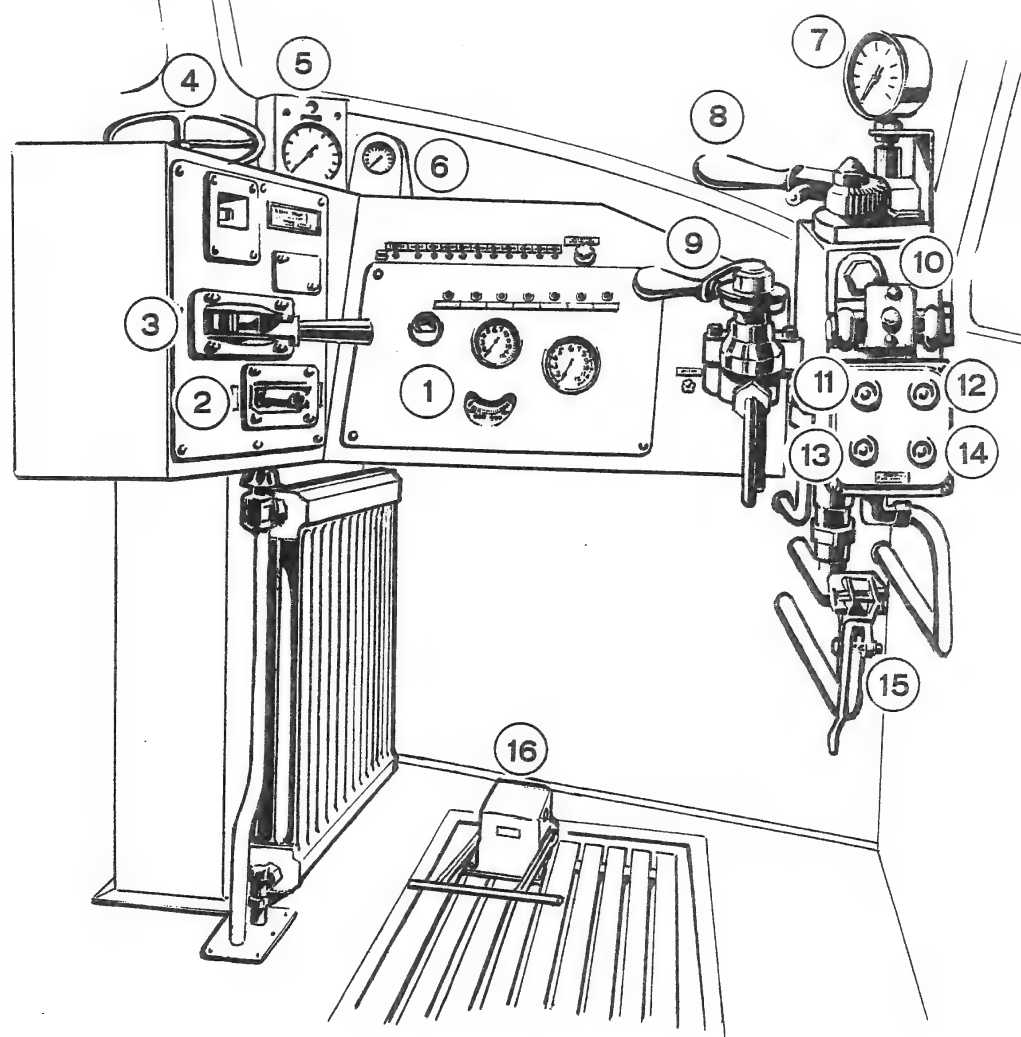
When the consist of the multiple unit locomotive includes two or more locomotives with operating controls, the procedure below should be followed in changing from one operating cab to the other.

1. Remove reverse lever.
2. Make a full service brake pipe reduction.
3. Move the independent brake valve handle to the NEUTRAL position.
4. Leave the automatic brake valve handle in the NEUTRAL position.
5. Place all switches in OFF position.
6. Proceed to cab at opposite end. Check PC switch light. Move control and governor switches to ON position and any other switches that are necessary.
7. Insert reverse lever and brake valve handles. Place independent brake valve in FULL APPLICATION position.
8. Place automatic brake handle in RELEASE position. Then place handle in RUNNING position.
9. When ready to move locomotive, depress safety control foot pedal (if used) and move independent brake valve to RELEASE position.

241. TRAILING CAB INSPECTION (MULTIPLE UNIT OPERATION)

Check the following:

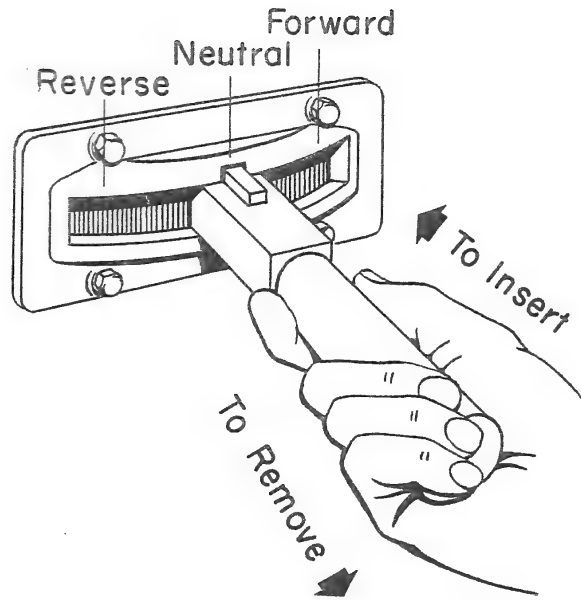
1. All switches should be in OFF position.
2. Throttle lever should be in IDLE and reverse lever removed from the control stand.
3. Independent brake valve should be in Release position.
4. Automatic brake valve should be in neutral position.
5. If engine is stopped, place the isolation switch in START. See Arts. 219 and 220 for engine starting instructions. If the engine is running, place isolation switch in RUN.
6. If engine is running, the battery ammeter should indicate zero or some charge.



- 1 Driver's Control Panel
- 2 Reverse Lever
- 3 Throttle Lever
- 4 Throttle Wheel
- 5 Speed Recorder
- 6 Steam Pressure Gauge
- 7 Time Reservoir Gauge
- 8 Automatic Brake Valve
- 9 Independent Brake Valve
- 10 Horn Button
- 11 Safety Button
- 12 Ground Relay Reset Button
- 13 Sanding Button
- 14 Steam Generator Blow Down Button
- 15 Emergency Brake Valve
- 16 Safety Foot Pedal

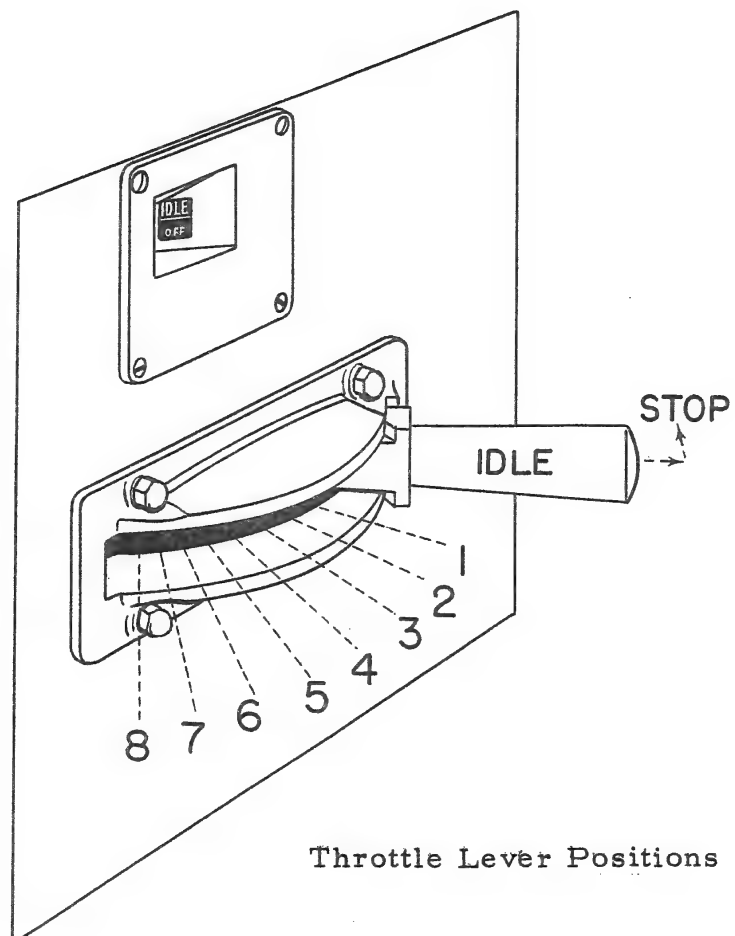
Driver's Control Stand

Fig. 2-2

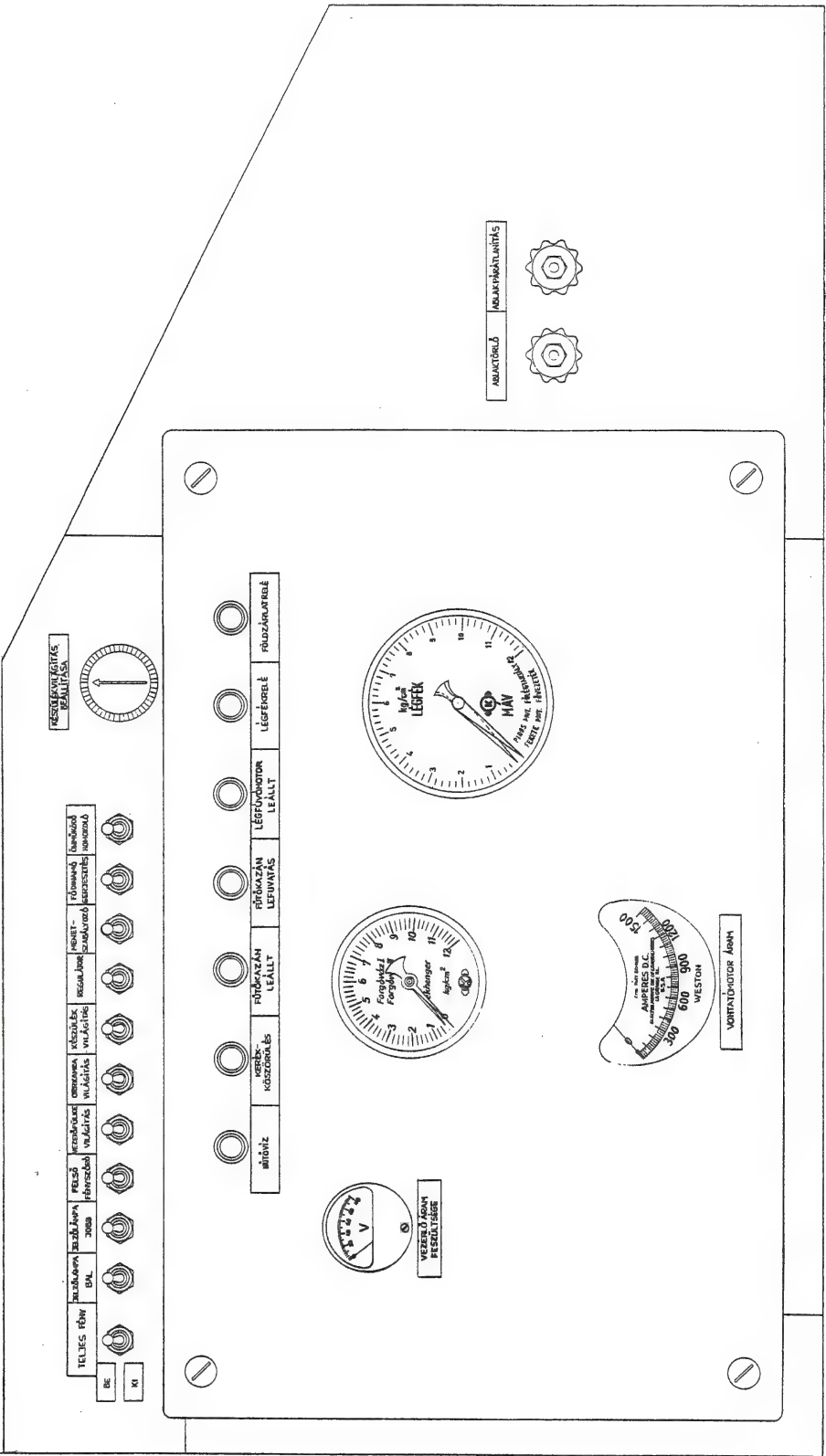


Reverse Lever Positions

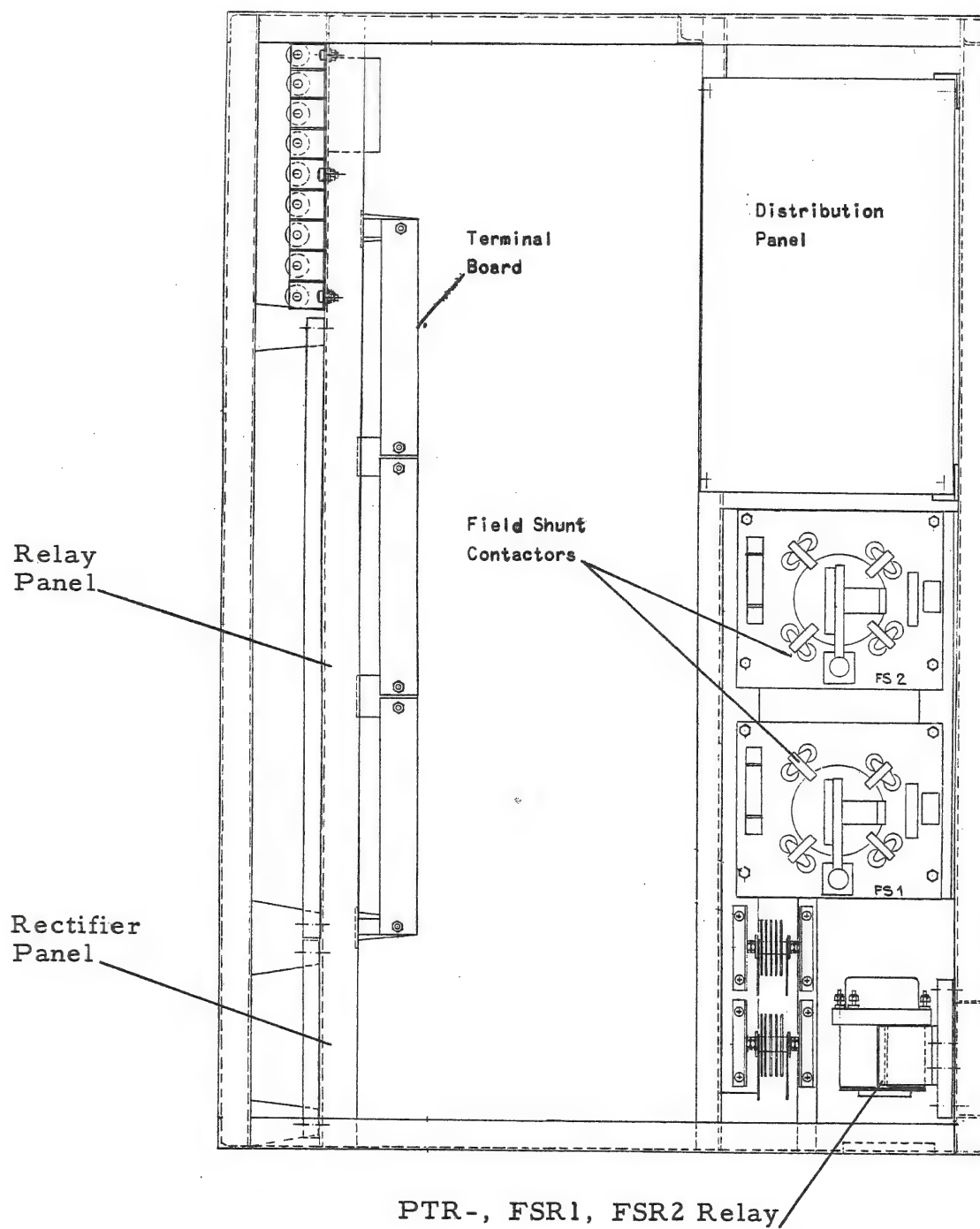
Fig. 2-3



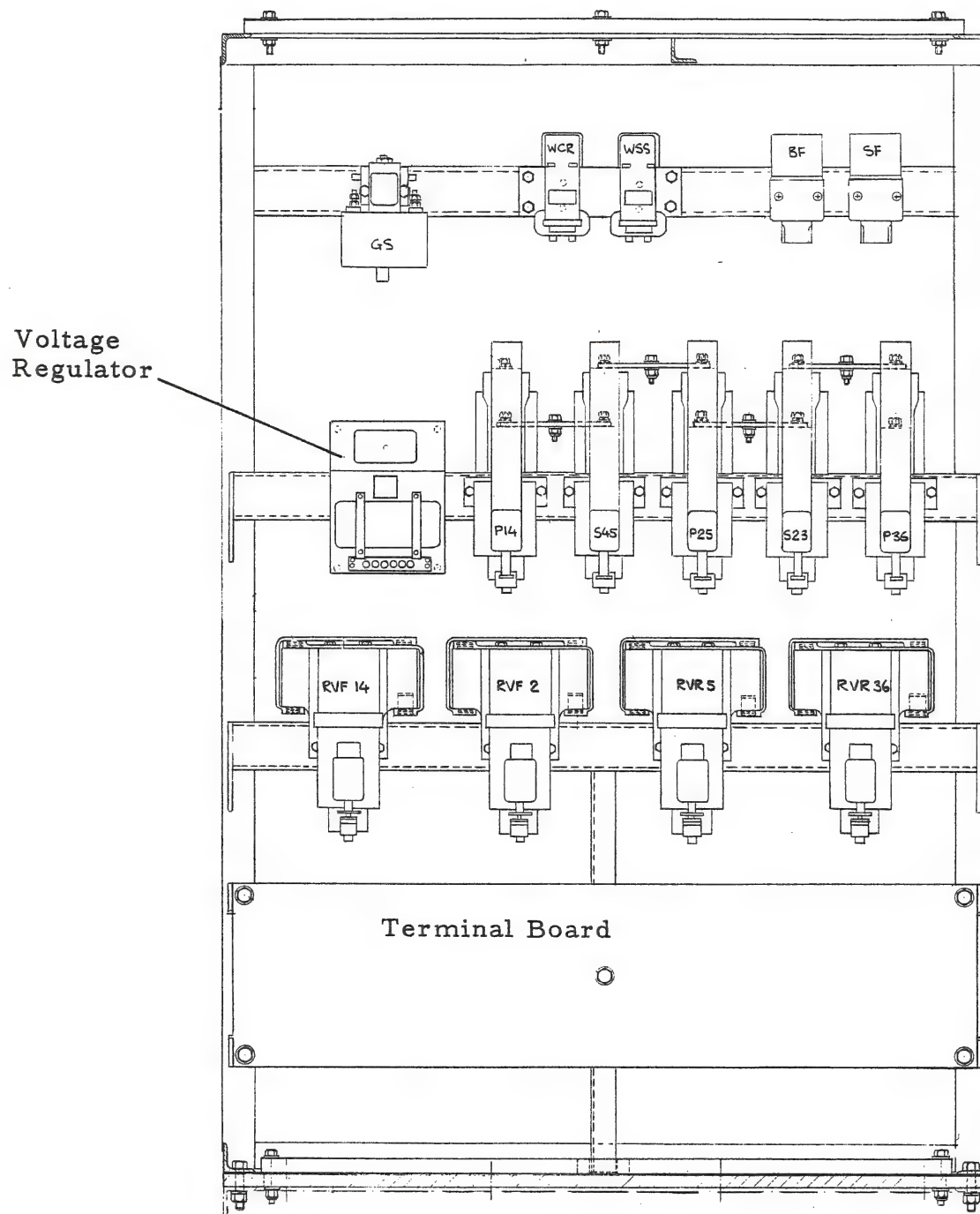
Throttle Lever Positions



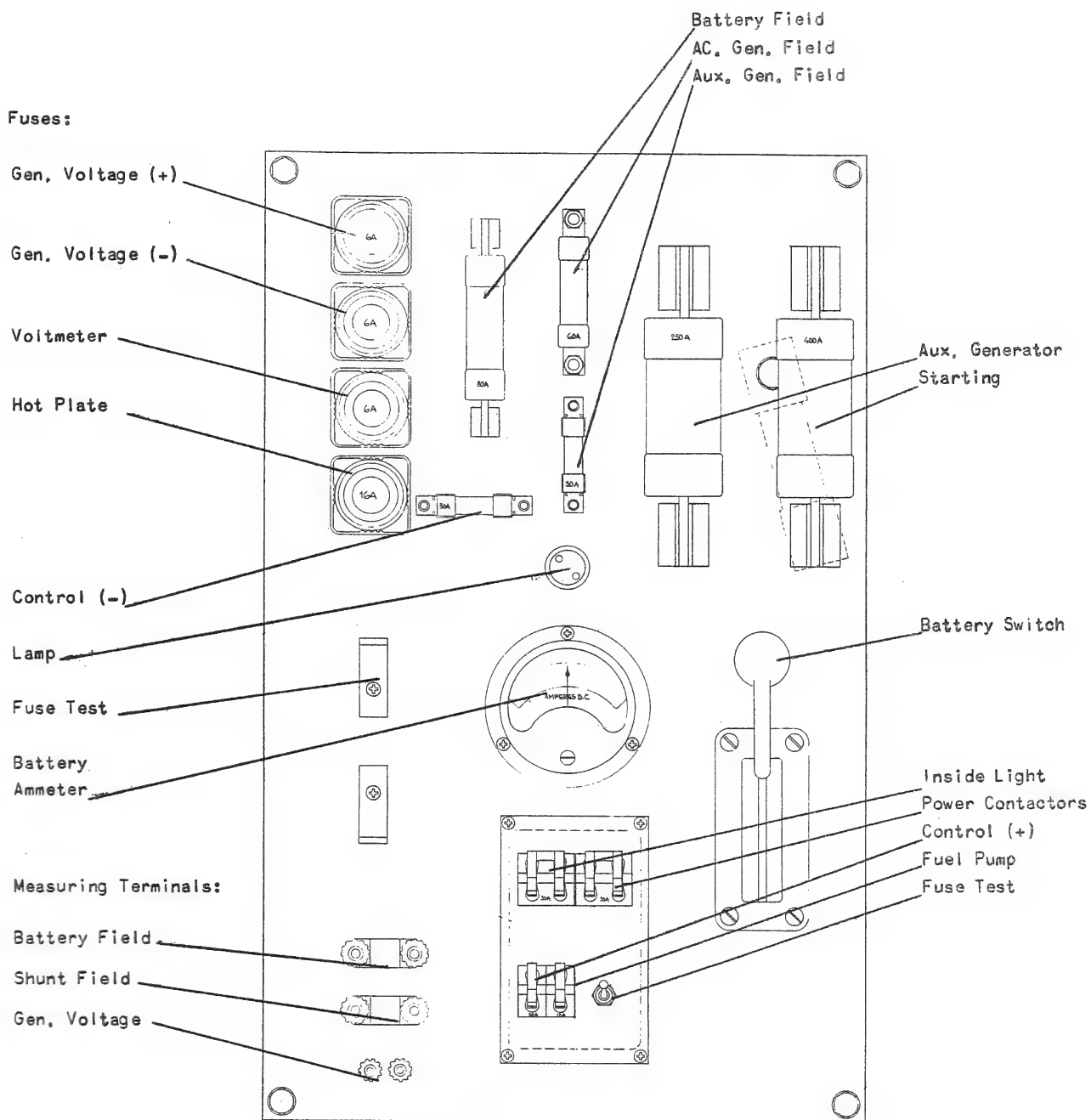
Driver's Control Panel



Cab Side
Electrical Control Cabinet



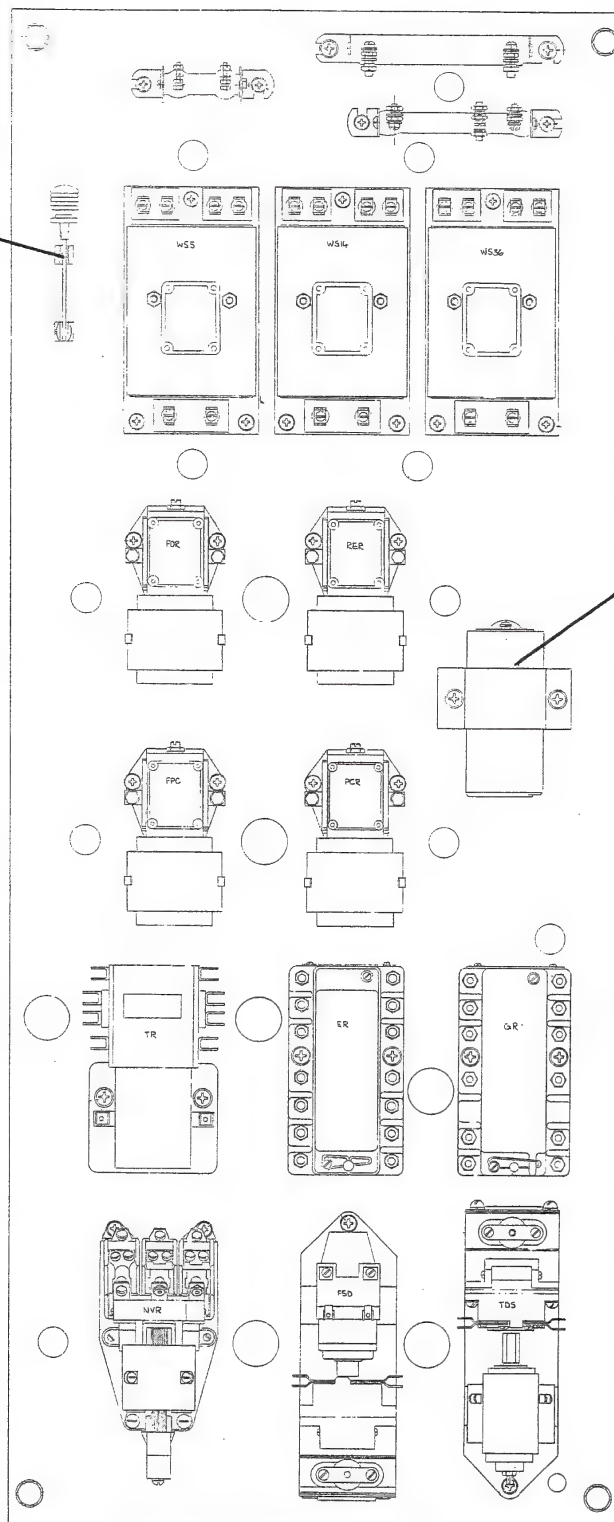
Contactors Arrangement
Electrical Control Cabinet



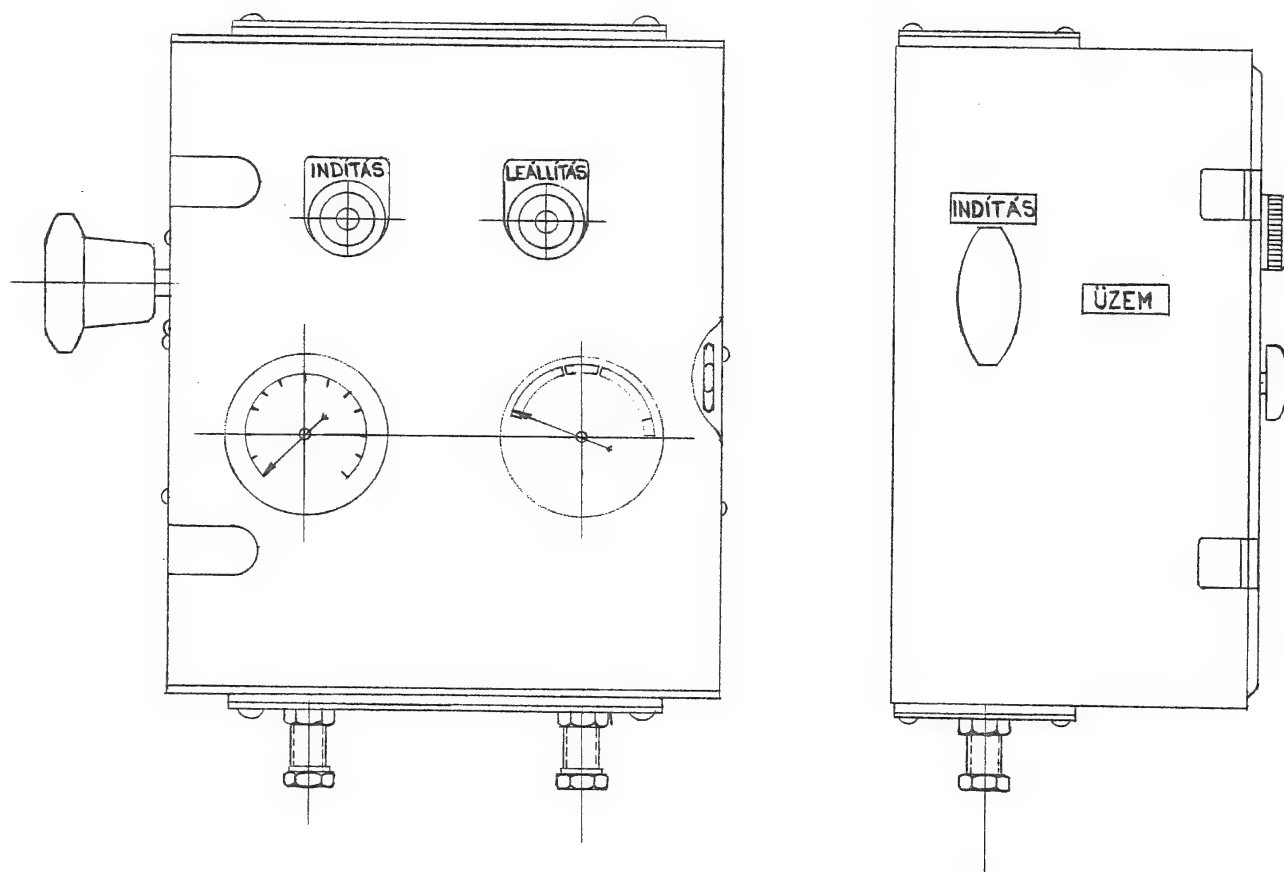
Distribution Panel
Electrical Control Cabinet

Ground Relay
Knife Switch

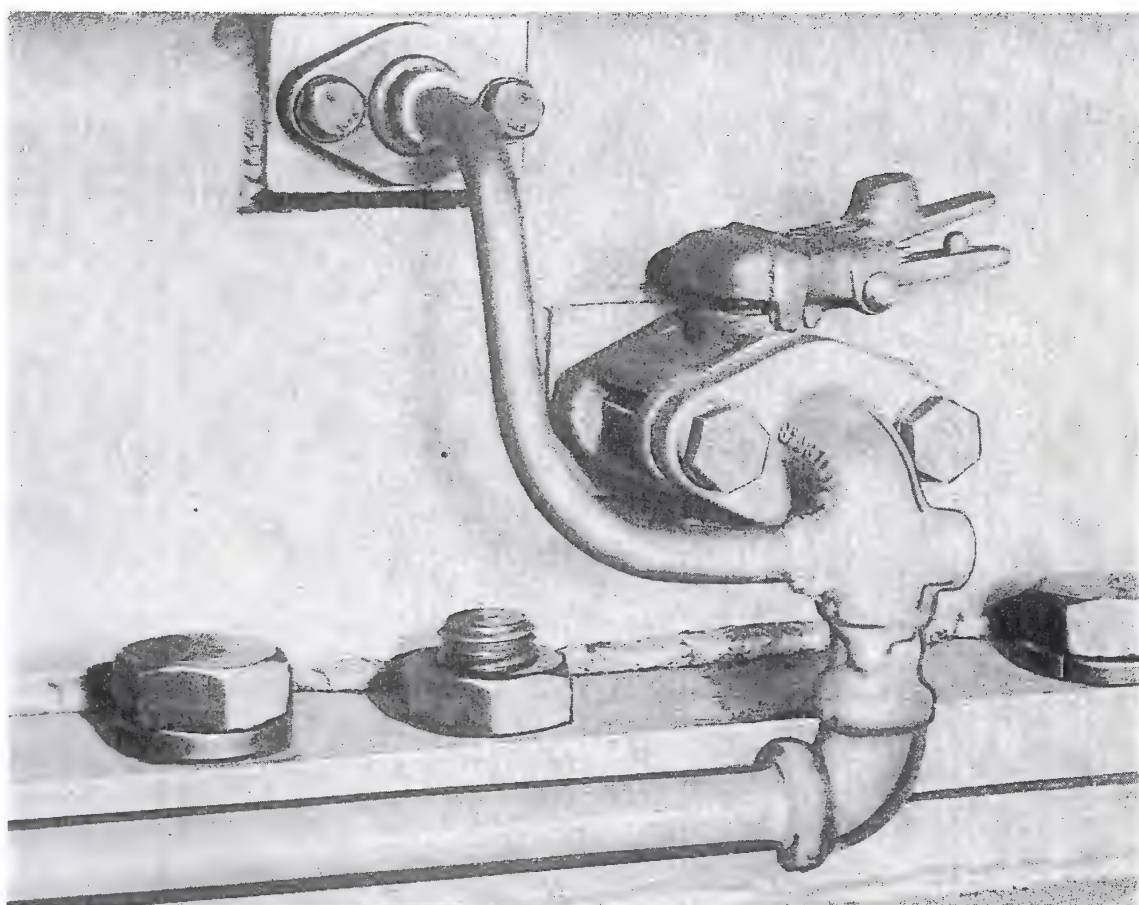
1000 μ F
Capacitor



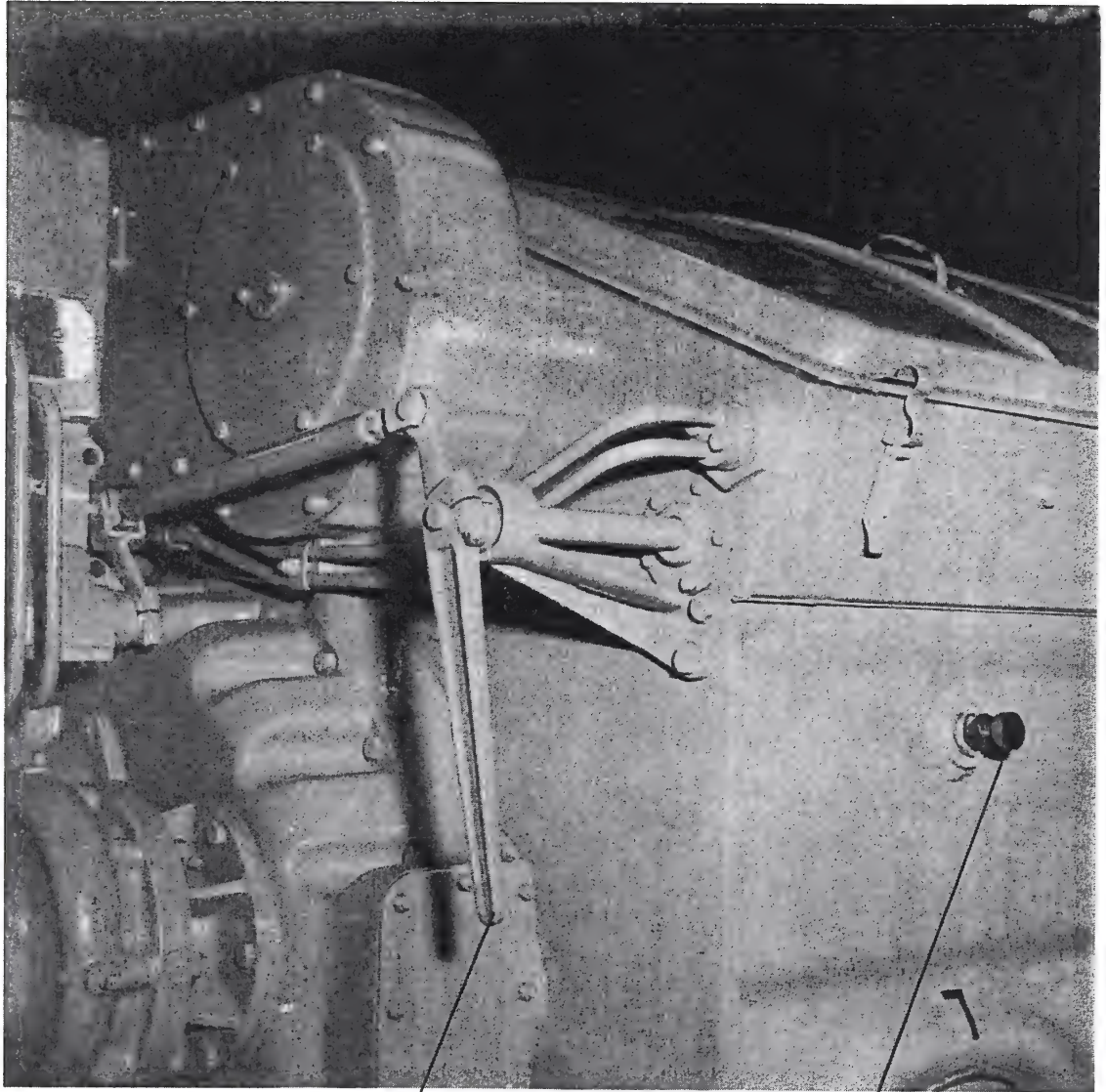
Relay Panel
Electrical Control Cabinet



Engine Control Panel

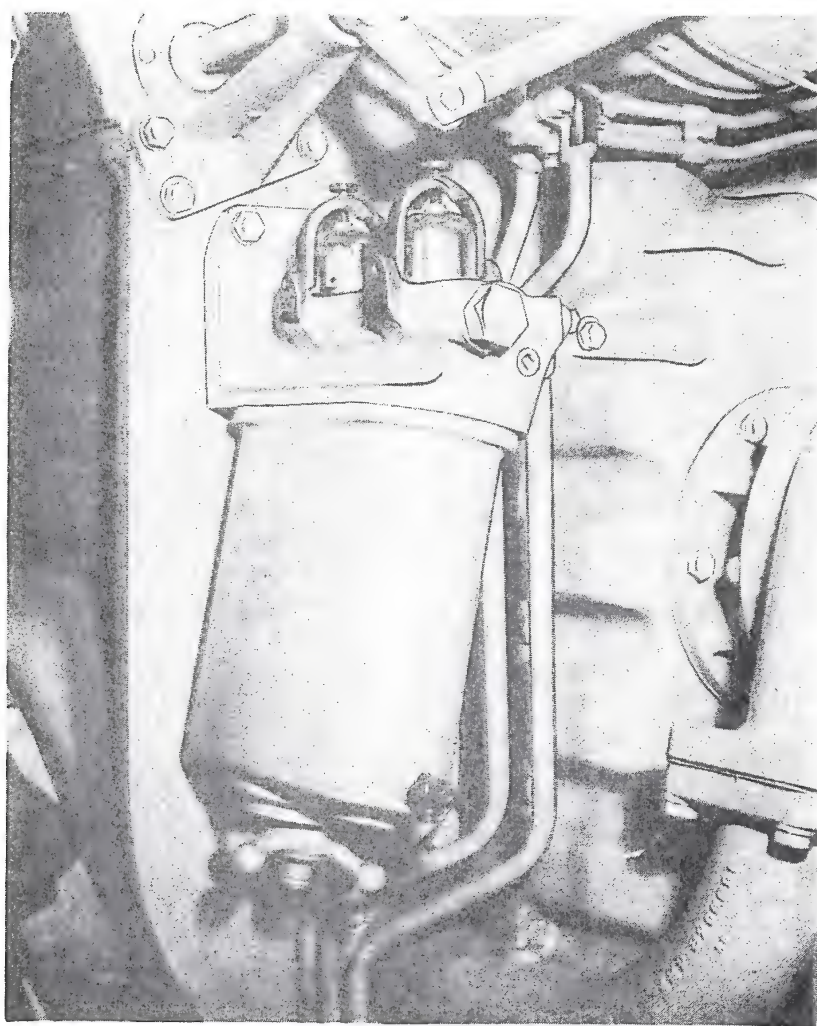


Air Box Drain Valve



Manual Layshaft

Test Valve



Fuel Sight Glasses

SECTION 3

MECHANICAL EQUIPMENT AND SYSTEMS

300. DIESEL ENGINE

The prime mover of the locomotive is a General Motors Model 567 D1 engine as shown in Fig. 3-1. This V-type engine has 16 cylinders and operates on the two stroke cycle principle. The cylinders have an 8-1/2" (216 mm) bore by a 10" (254 mm) stroke and are arranged at a 45° angle.

Uniflow scavenging is provided by two gear driven Roots type blowers located at the rear of the engine.

301. ENGINE OPERATING PRINCIPLE

In a four-cycle engine, four strokes of the piston are required to complete one cycle of events: the intake, compression power and exhaust strokes. The crankshaft will make two revolutions per cylinder for each power stroke. During the intake and exhaust strokes the piston functions as an air compressor which operation consumes power.

In a two-cycle engine, such as the model 567 D1 only two strokes of the piston are required to complete the cycle of events. Intake and exhaust takes place during part of the power and compression strokes. Each downward (power) stroke of the piston delivers a power impulse to the crankshaft. Therefore, a two-cycle engine has twice as many power impulses as a four-cycle engine, with the same number of cylinders and operating at the same speed.

As the piston in a two-cycle engine is not required to function as an air pump an external means of supplying air must be provided. A specially designed blower handling a large volume of air at low pressure, is used for this purpose. The blower forces air into the cylinder through ports in the cylinder wall, thus expelling the exhaust gases and filling the cylinder with a fresh charge of air for combustion.

The cycle of events of the two-cycle engine and operation of the blower are graphically described in Fig. 3-2 and explained in the following paragraphs.

Fig. 3-2A. At the lower end of its downward stroke the piston uncovers a row of ports in the cylinder liner admitting the scavenging air to the cylinder. This flow of air through the ports and exhaust valves produces complete scavenging, leaving the cylinder full of clean air when the piston covers the ports on its upward stroke.

Fig. 3-2 B. As the piston continues on the upward stroke the exhaust valves close and the charge of air is compressed to about 1/20-del of its initial volume and the air temperature increases. The high compression ratio is maintained at all loads and speeds.

Fig. 3-2 C. Shortly before the piston reaches the top dead center of its stroke, the fuel, atomized by high pressure, is injected into the combustion chamber. The fuel is ignited by the high temperature of the air and continues to burn until the charge is consumed. The burning charge rapidly builds up a high pressure which acts upon the piston, forcing it downward on the power stroke.

Fig. 3-2 D. Just before the piston reaches the end of the power stroke, the exhaust valves open, releasing the gases to the atmosphere. The piston then uncovers the air inlet ports. By this time the exhaust gases have expanded to the point where the pressure is lower in the cylinder than in the air box. The cycle is then repeated.

302. ENGINE INSTALLATION

The two ends of the engine are designated FRONT and REAR as shown in Fig. 3-3 which will serve to identify relatively, the cylinder locations, ends and sides of the engine as they are referred to in this manual. The governor, water pumps, and lubricating oil pumps are on the FRONT END or accessory end. The blowers, oil separator and the generator are mounted on the REAR END. The engine is placed so that its rear end is toward the front end of the locomotive when the unit is operating in the forward direction.

303. ENGINE SPEED GOVERNOR

The governor, Fig. 3-4, on the front end of the engine functions to control the speed of the diesel engine, as determined by the position of the throttle at the control stand. The speed of the engine is controlled from 275 RPM at Idle to 835 RPM in Run 8. The requirements of the various throttle positions are transmitted to the electro-hydraulic governor through electrical circuits. The governor is connected through a linkage to the injector control shafts on each bank of the engine. By regulating the position of the injector racks, and consequently the amount of fuel injected to each cylinder, the speed and power of the engine is controlled. The governor performs its job of seeing that the engine rotates at the speed ordered by the throttle, regardless of how much or little fuel may be needed.

Advice designated as the "load regulator" functions in conjunction with the governor to permit injection of no more or no less fuel to each cylinder than that which will result in the predetermined power output for each throttle position.

A low oil pressure device built into the governor protects the engine in case of low oil pressure, or high vacuum on the suction side of the pressure lubricating oil pump. In the event of such lubricating oil trouble, the governor will immediately stop the engine in that unit and ring the alarm horn in all units.

When the governor low oil pressure device stops the engine, a push button projects from the front of the governor housing and exposes a red band around the shaft of the button. This push button must be manually pressed IN (reset) to stop the alarm horn. The low oil button will not trip if the engine is stopped by any means other than oil trouble.

If an engine is stopped by the governor low oil device, the push button must be reset before the engine can again be started. When the engine is started and is running at idling speed, the governor will again stop the engine after approximately forty seconds, if the same condition exists which caused the original shutdown. The engine should not be repeatedly started if the governor continues to stop the engine. If an attempt is made to run the engine above idling speed during the delay period, the governor will immediately stop the engine if the oil pressure and suction are not correct.

304. ENGINE OVERSPEED TRIP

This device is located at the top front end of the engine and will trip to bring the engine to a stop if the engine speed should exceed approximately 910 RPM. Once this overspeed device is tripped, it must be reset manually by pulling the lever counterclockwise until it latches, before the engine can again be started see Fig. 3-5.

305. MANUAL LAYSHAFT LEVER

The manual layshaft control lever is attached to the end of the injector control shaft at the left front corner of the engine, as shown in Fig. 2-10.8. This lever may be used to manually shut down the engine, or to bring the speed to idle (as when taking an engine "off the line"). It may also be used to facilitate the starting of a cold engine.

306. COOLING SYSTEM

Water is circulated through the engine cooling system by two centrifugal type pumps mounted on the front end of the engine, Fig. 3-6. Cooling air through the radiator is controlled by shutters and four electrically driven cooling fans. The operation of the fans and shutters is entirely automatic and under normal conditions will keep the temperature of the engine cooling water at 77 - 83° C.

In the event of excessive cooling water temperature the high temperature alarm switch will close causing a red light to show in the unit affected and actuate the alarm horns in all units.

Five thermostats actuate the radiator fans the shutters and the alarm presaging too high a cooling water temperature. The thermostats are placed in a casing at the end of the hatch, in which the radiators are suspended. Some of the cooling water from the diesel engine passes through the above mentioned casing to be discharged into the cooling water tank.

The five thermostats are adjusted as follows:
(The thermostat switches close at the indicated temperatures and open at a temperature that is 6° lower.).

1. TA-thermostat: closes at 74° C, excites the electro-pneumatic shutter valve (SMW) and the contactor for radiator fan No. 1 (ACI). The shutters are opened and radiator fan No. 1 starts.

2. TC thermostat: closes at 76° C, excites the contactor for radiator fan No. 3 (AC3). Radiator fan No. 3 starts.
3. TD-thermostat: closes at 78° C excites the contactor for radiator fan No. 4 (AC4). Radiator fan No. 4 starts.
4. TB thermostat: closes at 82° C, excites the contactor for radiator fan No. 2 (AC2). Radiator fan No. 2 starts.
5. ETS-thermostat: closes at 98° C. The alarm horn thereby starts functioning and the signal lamp for the cooling water temperature is lit.

307. OPERATING WATER LEVEL

Level markings, are stenciled on the water tank next to the water gauge glass to indicate the minimum and maximum water levels, with engine running or stopped. The engine should not be operated with the water below the low water level. Progressive lowering of the water level indicates a leak which should be reported to the maintenance supervisor.

308. FILLING COOLING SYSTEM

The cooling system is filled through the filler pipes located just below the underframe on each side of the locomotive near the No. 2 bolster, or through the filler-vent pipe located on the roof of the locomotive.

To fill the cooling system proceed as follows:

1. Stop the engine.
2. Open the water level valve.
3. Slowly add water until it flows out the overflow pipe.
4. Turn off water at source.
5. Close the water level valve.

When filling a dry or nearly dry engine the following steps are also necessary:

6. Start the engine and run at idle speed for several minutes. This will purge the air from the cooling system.
7. Stop the engine and open the water level valve.
8. Add water until the level once again reaches the water level valve.
9. Shut off water at supply.
10. Close water level valve.

If the cooling system of a hot engine has been drained, do not refill immediately with cold water. The sudden change in temperature may result in damage to the engine cylinder liners and heads.

It is advisable to avoid overfilling the cooling system to prevent diluting any corrosion inhibitor in the system.

The cooling system can also be filled by an outside placed handpump.

309. DRAINING COOLING SYSTEM

The entire cooling system can be drained through the drain valve at the floor level in front of the engine, with the exception of the water which is trapped in the water pump on the right hand side of the engine. To drain the right hand water pump, open the drain valve on the bottom of the water pump housing.

310. LUBRICATING OIL SYSTEM

A schematic diagram of the lubricating oil system is shown in Fig. 3-7. Oil under pressure is forced through the engine for lubrication and piston cooling by the positive displacement combination piston cooling and lubricating oil pump. After circulating through the engine, the lubricating oil drains into the oil pan sump. A positive displacement scavenging oil pump draws oil from the sump through a strainer and forces it through the oil cooler and filter. From the filter, the oil is delivered to the oil strainer assembly where it is ready for recirculation by the piston cooling and lubricating oil pump. Since the scavenging oil pump delivers a greater quantity of oil to the strainer than is required by the lubricating oil and piston cooling pump, the excess oil returns to the oil pan sump.

Relief valves are placed in the lubricating oil system:

1. Five relief valve are built into the filter to allow the passage of oil to the strainer in excess of the capacity of the oil filter elements.
2. A relief valve is mounted on the left side of the accessory end of the engine. This valve is located in the discharge side of the lubricating oil pump. The purpose of this valve is to limit the maximum pressure of the lube oil entering the engine to approximately 70 psi (4,9 Kg/cm²). See Fig. 3-7 for location of engine mounted components of the lube oil system.

311. OIL PRESSURE

Adequate lubricating oil pressure must be maintained at all times when the engine is running. Upon starting and idling an engine it will be noted that the oil pressure builds up almost immediately. In the event of cold oil the pressure may rise to the relief valve setting.

The lubricating oil pressure is not adjustable. The operating pressure range is determined by such things as manufacturing tolerances, oil temperature, oil dilution and, of course, engine speed. Thus no specific operating pressures can be given. Generally, however, the lubricating oil pressure will be between 6 to 8 psi (0,42 to 0,56 Kg/cm²), at idle speed of 275 RPM and 50 to 55 psi (3,5 to 3,9 Kg/cm²) at full speed of 835 RPM. A lubricating oil pressure gauge Fig. 2-6 is mounted on the engine control panel. The minimum pressure at idle is 6 psi (0.42 Kg/cm²) and at full speed is 20 psi (1.40 Kg/cm²). Operation at pressures above these minimums is entirely satisfactory. A low oil pressure shutdown device built into the governor protects the engine against low engine oil pressure of high vacuum on the suction side of the pressure lubricating oil pump. In the event of insufficient oil pressure, the shutdown feature will automatically protect the engine by causing it to stop.

312. OIL LEVEL

The oil level should be checked, with the engine hot and running at idle speed. The dipstick should show a level between LOW and FULL, Fig. 3-8. The dipstick is located on the side of the engine. When the engine is stopped, the oil in the filter and cooler will drain back into the oil pan. If the oil level is checked with the engine stopped, the reading on the dipstick will be above the FULL mark.

313. ADDING OIL TO ENGINE

Oil may be added with the engine running or stopped. When oil is added to the system, it MUST be poured through the opening having the square cover, Tif. 3-9, on top of the strainer housing which is attached to the right front corner of the engine. Should the round caps be removed while the engine is running, hot oil under pressure will come from the openings and possibly cause personal injury. The Railroad Mechanical Department should be consulted for the recommended oil to be used for the engine.

OIL LEVEL CHECKS

In summation, the lubricating oil should be checked at the following places:

1. Diesel engine
2. Engine speed governor
3. Air compressor

314. FUEL OIL SYSTEM

A schematic diagram of the fuel oil system is shown in Fig. 3-10. Fuel is drawn from the storage tank through the fuel strainer by a motor driven gear type fuel pump. From the pump the fuel is forced consecutively through the engine mounted filter. After passing through the double element engine mounted filter the fuel flows to the injectors. The excess fuel which is not used by the injectors returns to the fuel tank through the return fuel sight glass located on the engine mounted filter housing. An orifice restricts the flow of fuel into the glass and causes a slight back pressure of fuel on the injectors. By maintaining this back pressure a positive supply of fuel for the injectors is assured as long as the fuel pump is operating.

Normally the fuel pump delivers more fuel to the engine than is burned in the cylinders. The excess fuel which is circulated through the injectors provides cooling and lubrication for the fine working parts of the injectors. For this reason, the engine should never be permitted to operate without adequate fuel flow showing in the sight glass.

315. FILLING FUEL TANKS

The fuel tank can be filled from either side of the locomotive. A short sight level gauge is located next to each fuel filler. This fuel gauge indicates the fuel level from the top to about 4-1/2" (11 cm) below the top of the tank and should be observed while filling the tank to prevent over-filling. DO NOT HANDLE FUEL OIL NEAR AN OPEN FLAME.

316. FUEL OIL LEVEL

An fuel oil level indicator in the engine room shows the quantity of oil from 0 to 3000 litres.

317. FUEL PUMP

The fuel pump is driven by a separate direct current electric motor through a flexible coupling. The pump assembly is mounted on the equipment rack which supports the engine cooling water tank. To operate the fuel pump the 30-ampere control circuit breaker, fuel pump circuit breaker, the four emergency fuel cut-off switches, and the control switch on the driver's control panel must be ON.

318. FUEL FLOW SIGHT GLASSES

Two sight glasses, Fig. 2-9, are located on the engine mounted filter housing to provide a visual indication of the condition of the fuel system.

For proper engine operation, a good flow of fuel clear and free of bubbles should be indicated in the sight glass nearest the engine, referred to as the 10-pound (0.7 Kg/cm^2), fuel return sight glass.

The engine mounted filter is also equipped with a 60 psi (4.2 Kg/cm^2) relief valve and sight glass, Fig. 2-9. This sight glass is referred to as the "60-pound sight glass", and is normally empty. When more than a trickle of fuel is seen in the 60-pound sight glass, it indicates that the relief valve is open. Fuel will pass through the 60-pound sight glass and relief valve to by-pass the engine and return to the fuel tank in case the dual element engine mounted filter becomes clogged. The engine should not be operated until the filtering elements are replaced to prevent damage to the injectors.

319. EMERGENCY FUEL CUT-OFF SWITCHES

In the event of an emergency the fuel supply to the engine may be cut off by turned off button of any of the emergency fuel cut-off switches. These switches are located on each side of the locomotive and on the front wall in both cabs. Fig. 3-11.

320. DRAINING FUEL TANK SUMP

Excessive water in the fuel system can cause considerable damage to the injectors, therefore a drain is provided on the fuel tank. Water can be drained from the tank by backing out the plug and allowing approximately one gallon (3.78 liters) to drain.

321. AIR SYSTEM

Compressed air is used on a diesel locomotive for operating the air brakes and sanders and is also essential for the proper operation of other components. Shutter operating cylinder, horn and windshield wipers are air operated. Some

of the items mentioned are electro-pneumatic valves which means that in such cases the flow of compressed air, through the valve, is controlled by electrical circuits. The compressed air then supplies the power to actuate the apparatus to which is connected.

Each locomotive power plant is basically equipped with air-cooled 2-cylinder, two-stage air compressor, Fig 3-12. The air compressor is driven by an extension shaft through a flexible coupling from the front end of the diesel engine.

322. AIR COMPRESSOR

The compressor consists of one low pressure cylinder and one high pressure cylinder. The pistons of the two cylinders are driven by a common crankshaft. The low pressure cylinder is set at an angle to the high pressure cylinder. Air from the low pressure cylinder goes to an intercooler, or radiator, to be cooled before entering the high pressure cylinder. The intercooler is provided with a pressure gauge and relief valve. The gauge normally indicates approximately $1,9 \text{ kg/cm}^2$ when the compressor is loaded.

Condensation and oil collect in the sump of the bottom header of the compressor intercooler and should be drained off, once at each crew change and at the regular maintenance period. Two drain valves are provided in the bottom header for this purpose.

The compressor has its own oil pump and pressure lubricating oil system. With the engine stopped, the oil level in the compressor crankcase can be checked at the dipstick on the side of the compressor crankcase.

323. COMPRESSOR CONTROL

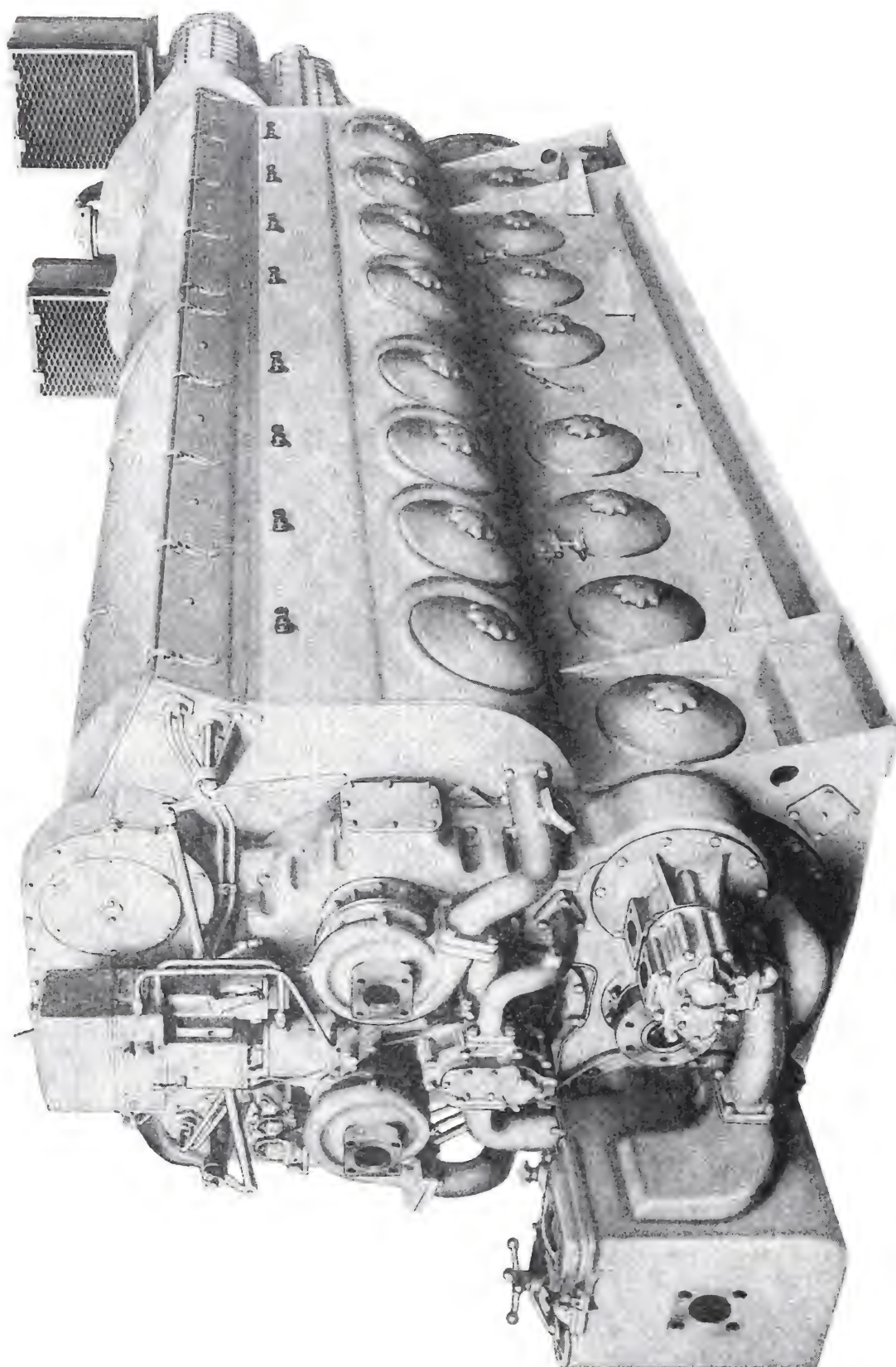
The air compressor is directly connected to the engine, and is in continuous operation (although not always pumping air) whenever the engine is running. An unloader piston is provided in the head of the high and low pressure cylinder which functions to prevent the compressing action as influenced by air pressure from the compressor governor control. The unloader accomplishes this by holding open the intake valves of the high and low pressure cylinders. When the air which operates the unloader is shut off, the unloader mechanism releases the intake valves and the compressor resumes operation. Main reservoir air pressure is used to actuate the unloader valves.

With the pneumatic governor control system each air compressor operates as an individual component without regard to the main reservoir demands of other units in the consist. When the main reservoir air pressure reaches 11 kg/cm^2 the governor "cuts out" the air compressor by admitting air to the unloader valves. The admission of compressed air to the unloader valve will hold the intake valves open, and stop the compressing action. The compressor remains unloaded until the main reservoir pressure decreases to $10,3 \text{ kg/cm}^2$. The governor then "cuts in" the air compressor by stopping the air supply to the unloader valves, releasing the intake valves, and the compressor resumes normal operation.

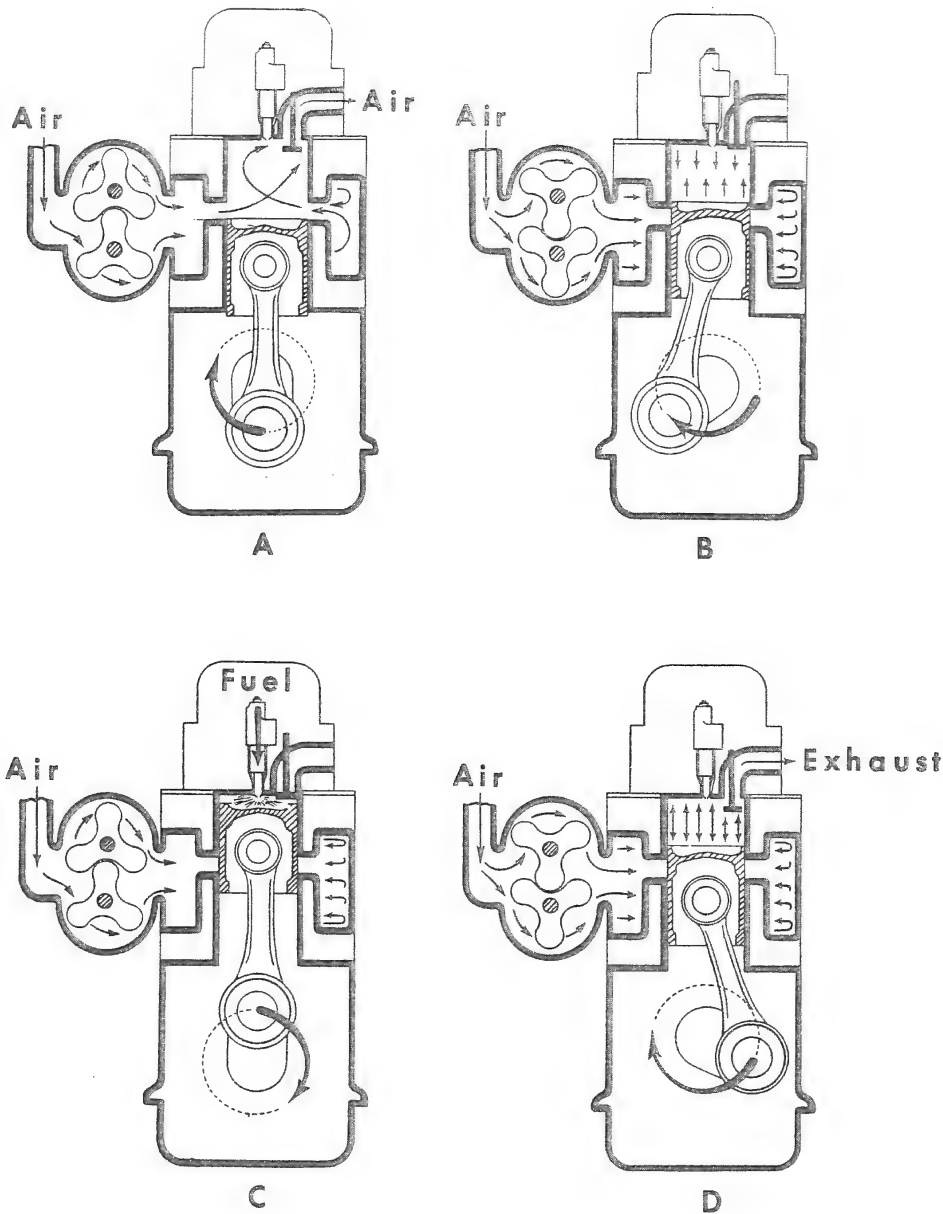
324. The Manual Unloader Valve is mounted in the governor control.

325. DRAINING OF AIR SYSTEM

The air system should be drained periodically to prevent moisture from being carried into the air brake system. The frequency of draining will depend on local conditions and can be determined by practice. It is recommended that draining be done at the time of each crew change, until a definite schedule can be determined by the individual railroad.

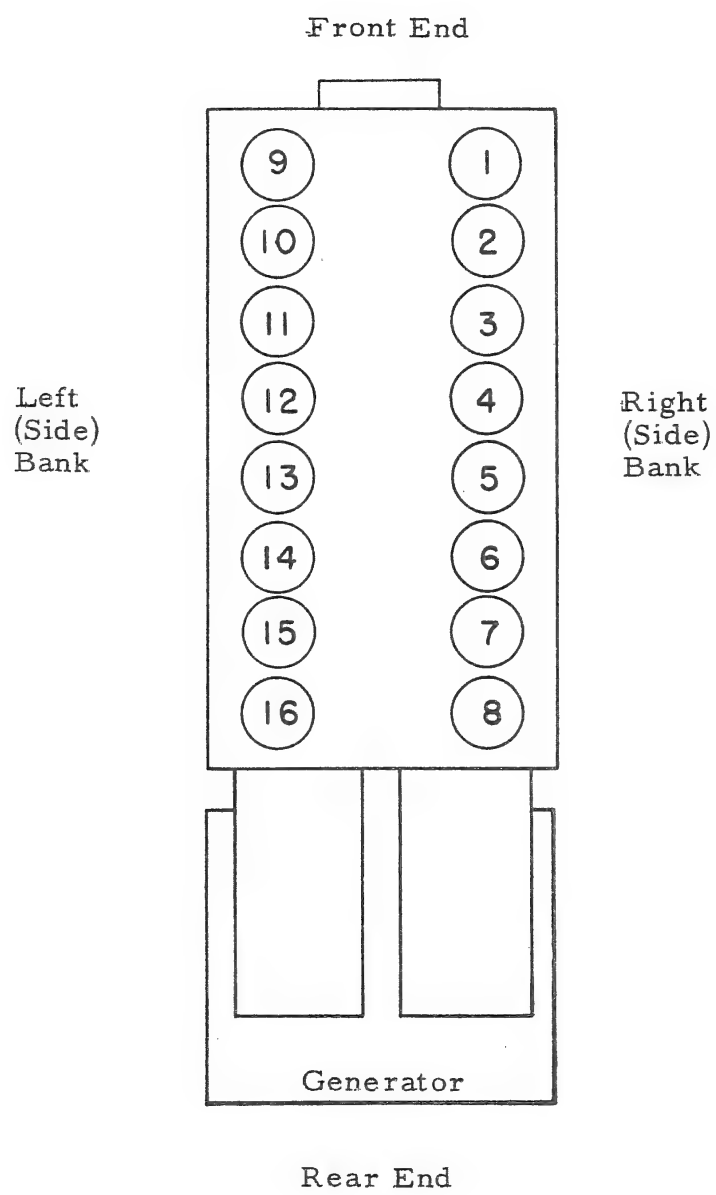


16-567 D1 Engine

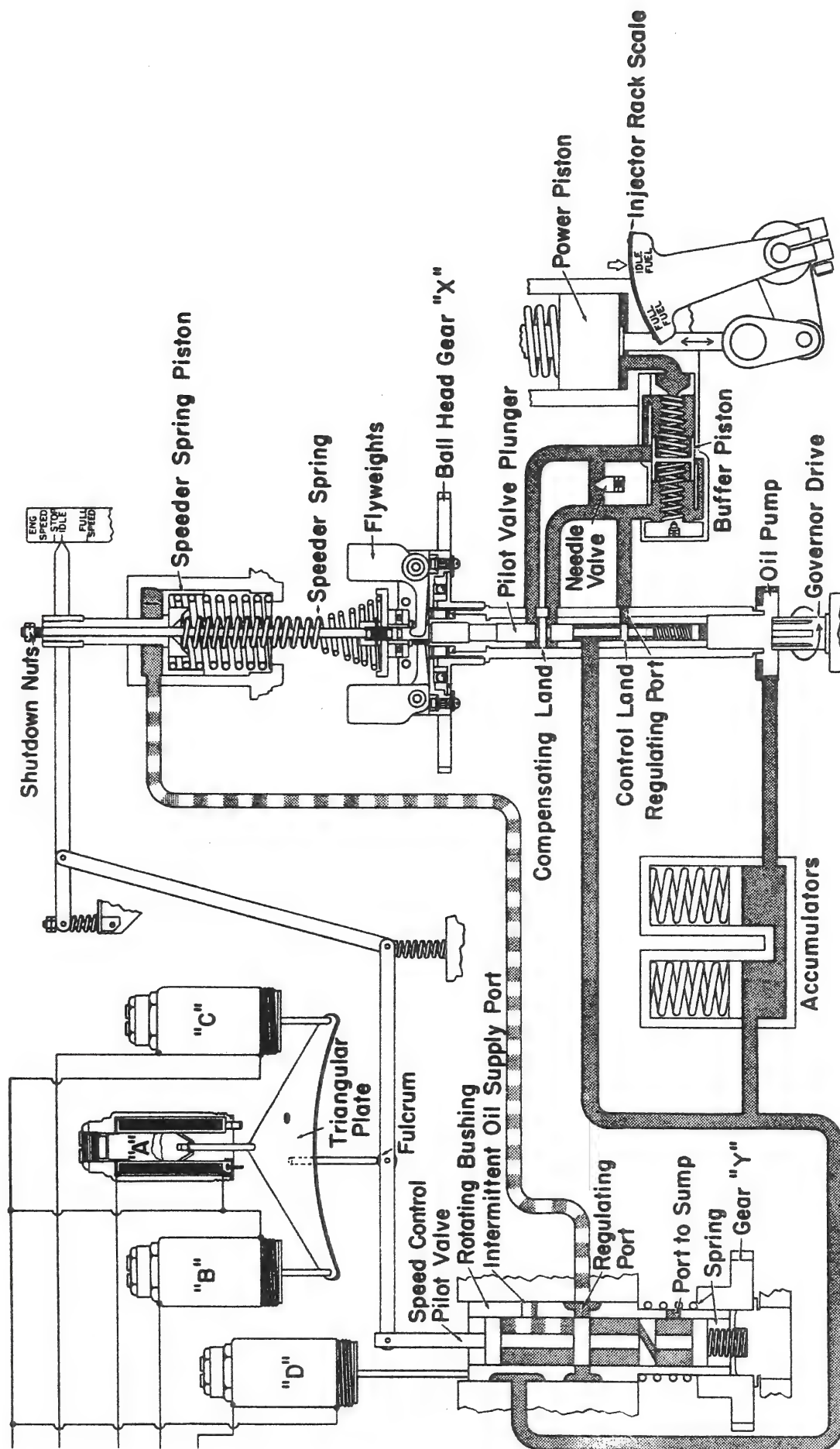


FOUR-CYCLE			
INTAKE STROKE	COMPRESSION STROKE	POWER STROKE	EXHAUST STROKE
TWO REVOLUTIONS OF THE CRANK SHAFT			
INTAKE	COMPRESSION STROKE	POWER STROKE	EXHAUST
INTAKE	COMPRESSION STROKE	POWER STROKE	EXHAUST
TWO-CYCLE			

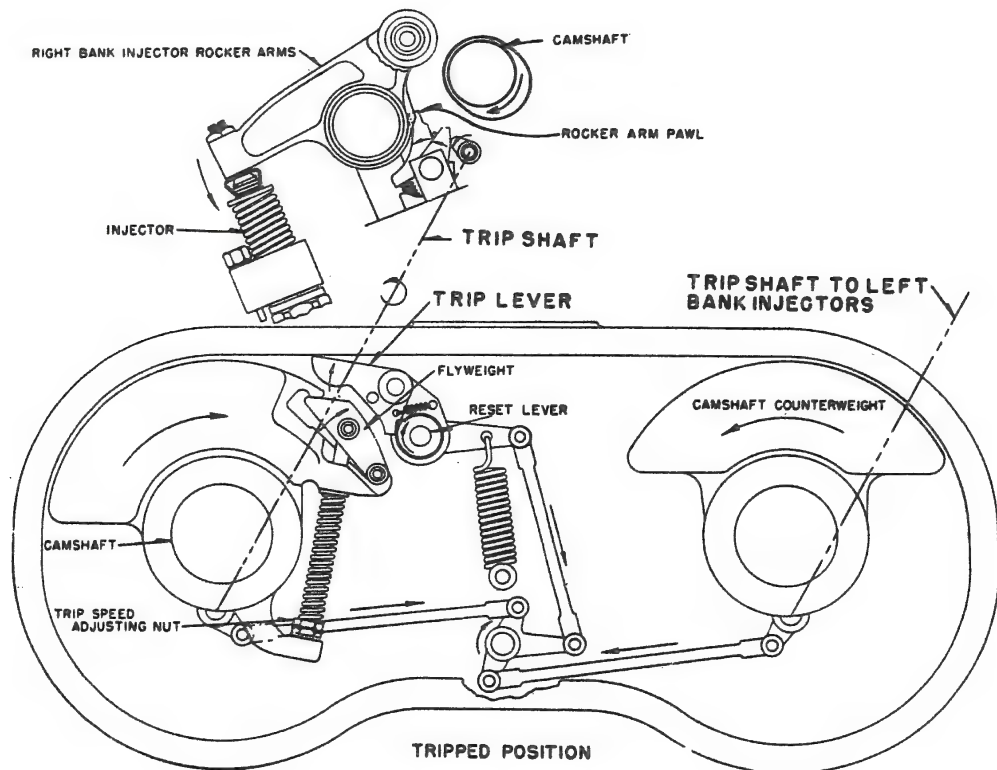
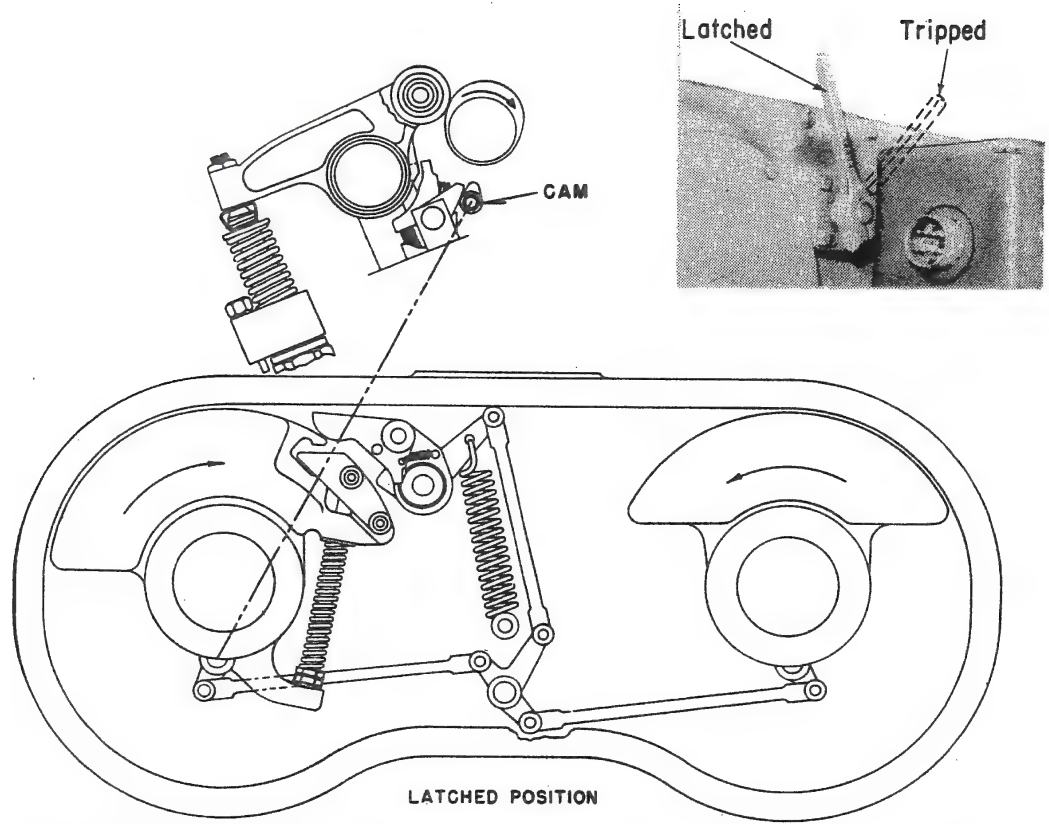
Cycle Of Events Of Engine



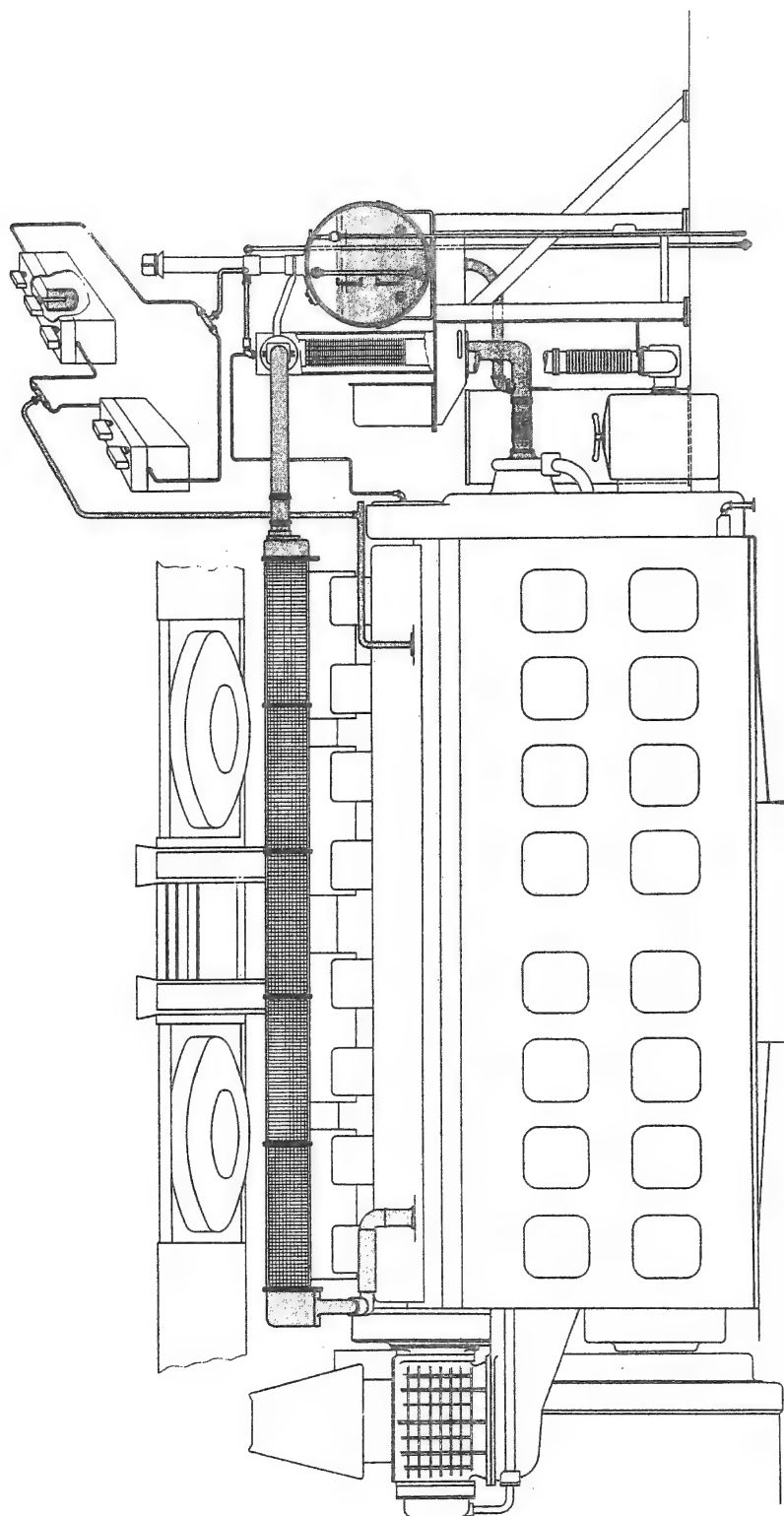
Cylinder Arrangement



Schematic Operating Diagram Electro-Hydraulic Governor

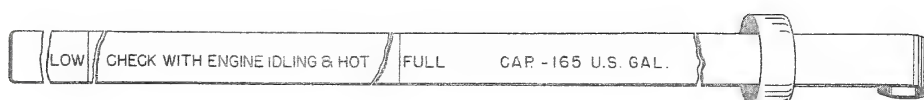


Overspeed Trip



Cooling System Schematic

Fig. 3-8



Lube Oil Dipstick

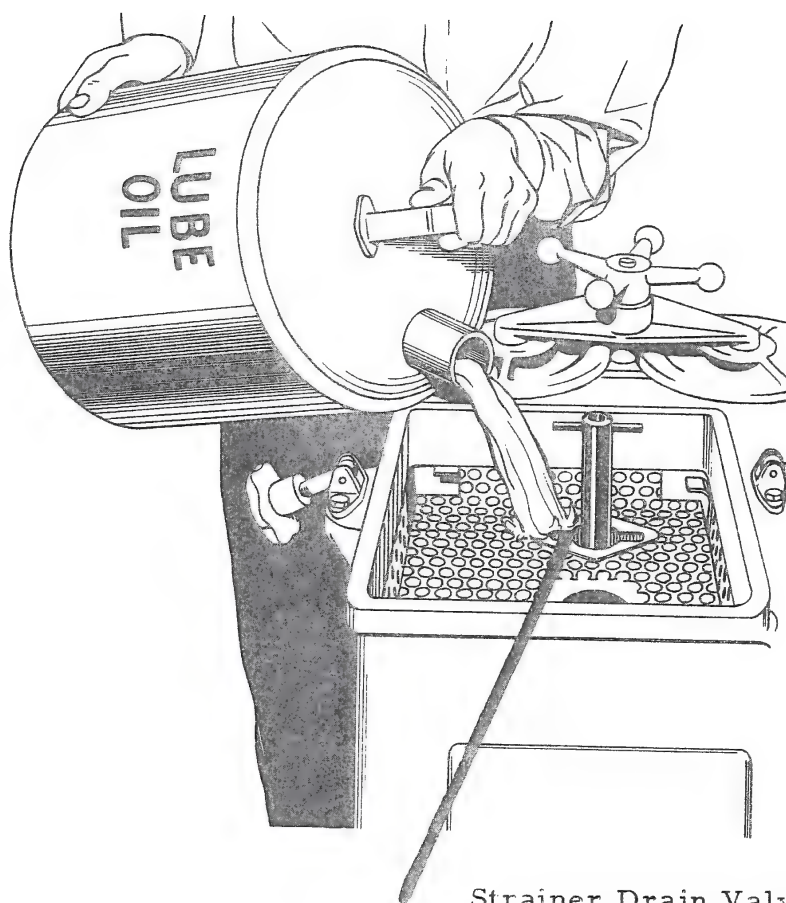
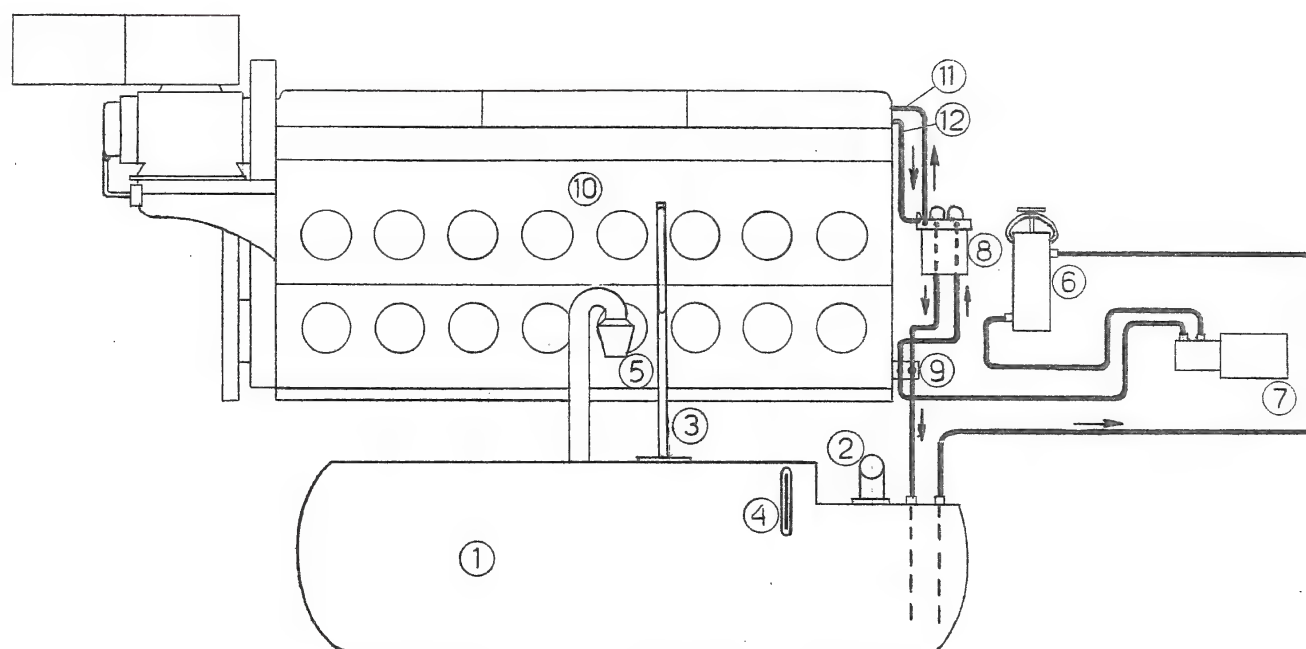


Fig. 3-9

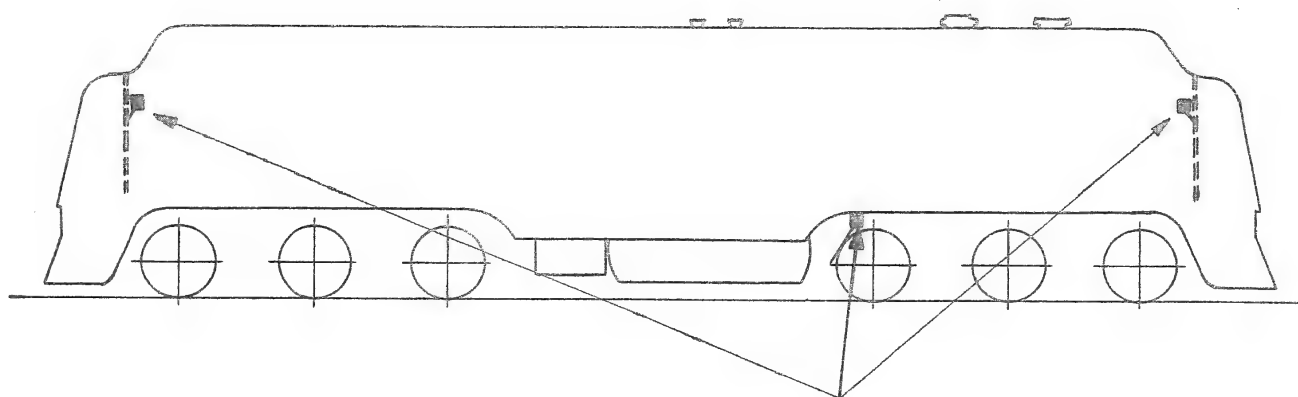
Strainer Drain Valve
Open Only If Draining
The Engine Oil Pan

Adding Oil To Engine

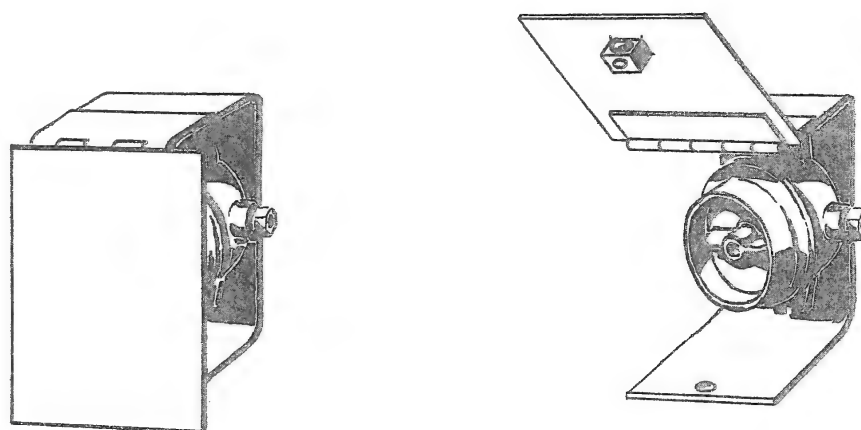


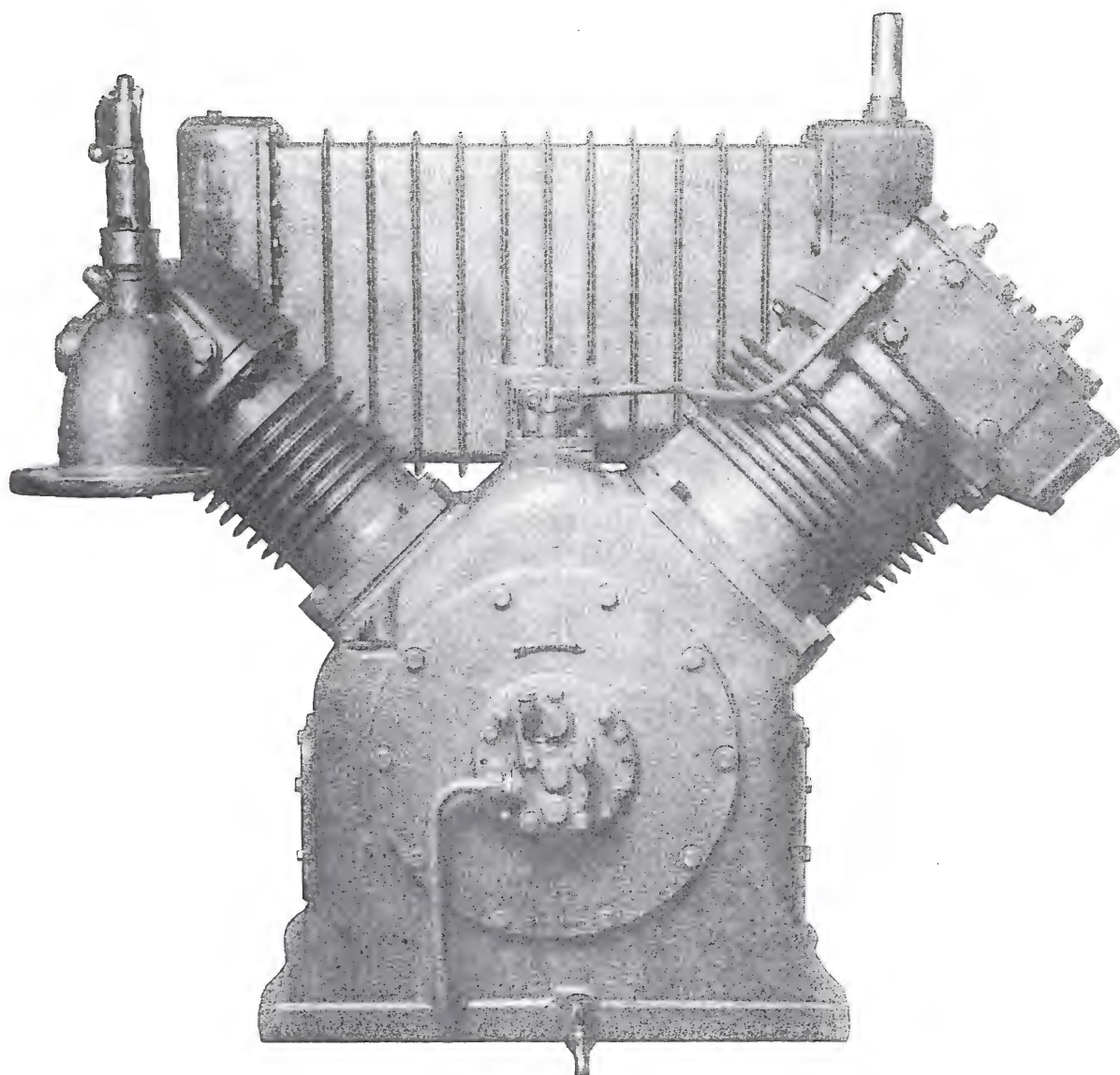
1. Fuel Tank
2. Filler
3. Oil Level Indicator
4. Sight Level Gauge
5. Flame Arrester
6. Fuel Strainer
7. Fuel Pump
8. Filter and Sight Glasses
9. Fuel Supply and Return Housing
10. Engine
11. Fuel Supply to Injectors
12. Fuel Return from Injectors

Fuel Oil System



Emergency Fuel Cut-Off Switches





Compressor

SECTION 4

ELECTRICAL EQUIPMENT

400. BASIC ELECTRICAL SYSTEMS

In full throttle, the rated horsepower of the engine is delivered to the direct coupled main generator. At the main generator the power of the engine is transformed into electrical power. The electrical power is then conducted to the six traction motors, three motors being located in each truck (each motor being geared to an axle).

The locomotive is designed so that within the current and voltage limits of the main generator, the power (KW) delivered to the traction motors at full throttle, is the same, regardless of the locomotive's speed.

The electrical system of the locomotive can be thought of as being divided into three separate systems:

1. High voltage system
2. Low voltage system
3. Alternating current system

The high voltage system is directly concerned with moving the locomotive. The main components of the high voltage system are the main generator, traction motors, transition relays, shunt field contactor, motor shunting contactors, reversing contactors, wheel slip relays, ground relay, series and parallel power contactors.

The low voltage system contains the control circuits which control the flow of power in the high voltage system, and those auxiliary circuits conducting power of the locomotive lights, fuel pump and the main generator battery field. A 64 volt battery, in the low voltage system, is the source from which power is taken to start the Diesel engine. Once the engine is started, the auxiliary generator takes over the job of supplying power to the low voltage system.

The alternating current system includes an alternating current generator (called an alternator), four engine cooling fan motors, and six traction motor blower motors. The alternating current system provides a means of driving accessories, without the use of belt drives, at speeds which vary according to the speed of the engine.

In order to achieve a better understanding of the equipment described in this section it is recommended that reference be made to the glossary of electrical terms, the legend of electrical equipment, and the explanation of electrical symbols at the end of this section.

LOW VOLTAGE SYSTEM

The source of power for the low voltage system is from either the storage battery (engine stopped) or the auxiliary generator (engine running).

401. STORAGE BATTERY

Power from a 48 cell, 64 volt storage battery is used to start the diesel engine. The storage battery compartments are located beneath the under-frame in front of the fuel tank on each side of the locomotive with 24 cells in each compartment. With the diesel engine running, the auxiliary generator charges the storage battery and supplies the low voltage current requirements.

402. AUXILIARY GENERATOR

A 18 KW auxiliary generator is driven directly from the rear gear train of the engine through flexible couplings. The auxiliary generator produces direct current at 74 volts to charge the storage battery and supply the low voltage circuits for lighting, control, main generator battery field excitation, fuel pump and steam generator operation.

403. VOLTAGE REGULATOR

The voltage regulator is located in the rear of the electrical cabinet. It maintains the output of the auxiliary generator at approximately 74 volts regardless of engine speed. Fig. 4-1.

The voltage regulator controls the auxiliary generator voltage by regulating the excitation of the auxiliary generator field. With an increase in engine speed the auxiliary generator voltage tends to increase. The voltage regulator reacts to decrease the current in the auxiliary generator field which acts to prevent an increase in output voltage.

404. BATTERY AMMETER

The battery ammeter, located on the distribution panel in the electrical cabinet, Fig. 2-5, shows whether the battery is charging or discharging. Normally the meter will indicate zero or a slight charge. If the ammeter shows a continual discharge, with the engine running, the auxiliary generator output should be checked or the battery may become depleted.

405. BATTERY CHARGING RECTIFIER

The purpose of the rectifier is to prevent a reverse flow of current from the battery to the auxiliary generator. The rectifier is located in the engine room behind the electrical cabinet.

406. SHUNT FIELD (SF) AND BATTERY FIELD (BF) CONTACTORS

These contactors are electrically operated devices which, when energized, will complete the circuits necessary to excite the main generator so that it generates electrical power. If the BF is de-energized the unit will not deliver power. Fig. 2-5.

407. MAIN BATTERY KNIFE SWITCH

This switch when closed connects the battery to the low voltage circuits. To start the engine and during normal locomotive operation, the main battery switch must be closed. Fig. 2-5.

408. ENGINE RELAY (ER)

The engine relay (ER) establishes the circuits, through its interlocks, to the A, B and C solenoids in the engine governor. The ER must be energized in order for the driver to control the engine speed. Fig. 2-5.

409. FUSES

Fuses are electrical safety devices which protect the equipment from damage caused by current overloads.

In the electrical cabinet, Fig. 2-5, on the distribution panel are the following fuses:

Amperage	Name
80	Battery Field
250	Aux. Generator
30	Aux. Gen. Fld.
30	Control (-)
400	Starting
60	AC Gen. Field
16	Hot Plate
6	Voltmeter
6	Measuring Terminal (+)
6	Measuring Terminal (-)

On the rear of the driver's control stand are three fuses for the headlights.

HIGH VOLTAGE SYSTEM

The main components of the high voltage system are the main generator, traction motors, power contactors, reversing contactors, wheel slip relays, ground relay, shunt field contactor, motor shunting contactors, and transition relays.

410. MAIN GENERATOR

The main generator is a specially designed constant kilowatt (power) generator. A specific amount of electrical power will be produced from the input of a specific amount of mechanical power. Since power in watts is the product of the volts times the amperes, it is obvious that with a constant kilowatt generator, when the voltage increases the amperage decreases, and vice versa, when the voltage decreases the amperage increases.

Main generator voltage is nominally 600 volts but varies with operating conditions. The output voltage of the main generator is controlled by the amount to which the main generator is excited, and the speed of armature rotation.

The main generator contains six field windings:

Starting, battery, shunt, differential, compensating and commutating. The starting field is used only when the main generator is used as a starting motor to rotate the engine. With regard to locomotive operation, the shunt and battery fields provide the major excitation of the main generator.

The battery field provides the initial excitation of the main generator and is a low voltage, externally excited field. The current flowing through the battery field is varied by the action of the load regulator. By varying the strength of the battery field, the power output of the main generator is largely controlled.

The main generator is self-excited by the shunt field. The shunt field is a high voltage field whose excitation varies with the voltage of the main generator. A shunt field contactor opens or closes the circuit to the shunt field.

The differential, compensating and commutating fields are permanently connected and are a matter of engineering design providing desired generator characteristics and proper commutation.

411. TRACTION MOTORS

The traction motors are direct current, series wound motors geared to the driving axles. Their maximum permissible top speed is limited by the safe rotational speed of the armature, thus the necessity for gear ratios.

The motors are reversed by changing the direction of current flow in the field windings, the direction of current flow in the armature always being the same. This is accomplished by four reversing contactors, two of which (RVF14 and RVF2) are energized for forward operation and two others (RVR36 and RVR5) for reverse.

The traction motors are cooled by alternating current driven blowers, one for each motor. The traction motor blowers are mounted on the floor of the engineroom and blow air through flexible ducts to the traction motors. The speed of the blowers varies with the speed of the engine; this is due to the engine speed varying the frequency of the alternator.

412. POWER CONTACTORS

The power contactors S23, S45, P14, P25 and P36 are electrically operated single pole devices which are used to connect the traction motors to the main generator. Different combinations of power contactors are used in the several steps of transition. Fig. 2-5.

413. REVERSING CONTACTORS

Movement of the reverse lever at the driver's control stand to the forward or reverse position energized the Forward Relay (FOR) or Reverse Relay (RER). These relays, in turn, complete circuits to their associated contactors. These contactors determine the direction of current flow through the field windings of the traction motors to give the desired direction of movement to the locomotive.

The reversing contactors are electrically operated double pole switches. The contactors governing forward movement are RVF14 and RVF2. Those necessary for backward movement are RVR36 and RVR5. Fig. 2-5.

414. GROUND RELAY (GR)

Located on the relay panel in the el. cabinet is an electrical protective device called the ground relay. The function of the ground relay is to automatically unload the main generator in case of a ground in the high voltage system. A ground can be defined as an undesirable condition in which a portion of either the high or low voltage system becomes connected to the frame or carbody of the locomotive. It is not possible to receive a shock from this condition.

The ground relay knife switch, when open, eliminates the protection of the ground relay. This switch MUST NOT BE OPENED in normal operation unless definite instructions are issued by an official of the railroad. It is intended for use of the maintenance forces during certain electrical tests. Fig. 2-5.

415. MOTOR SHUNTING CONTACTORS (FS1, FS2)

The traction motor field shunting contactors are found in the front of the electrical cabinet. They are used to shunt the traction motor fields in two of the stages of transition. Fig. 2-5.

416. TRANSITION RELAYS

The transition relays are called field shunting relays (FSR1 and FSR2) and parallel transition relay (PTR).

Their purpose is to initiate the change in the traction motor connection to the main generator in order that full power may be obtained from the main generator, within the range of its current and voltage limits.

417. ER RELAY

The ER relay controls the current supply to the A, B, and C governor control solenoids. De-energizing this relay will cause the engine to immediately stop if the throttle is in Run 5 or 6. De-energizing the ER relay in any other throttle position will bring the engine to idle.

To control the engine speed in any unit the ER relay in that unit must be energized. The ER relay has three normally open interlocks which will close, when the relay is energized, to connect the control circuits

to the A, B, and C governor control solenoids. Fig. 2-5. The ER relay has no control of the D governor control solenoid.

418. BATTERY FIELD CONTACTOR AND FUSE

When the throttle is moved from Idle to Run 1, this contactor closes and connects low voltage excitation to the main generator battery field. The battery field contactor remains closed as long as power is being applied, but will open during transition and wheel slip action. A rectifier and discharge resistor are used to dissipate the high voltage induced in the battery field when the battery field contactor is opened.

An 80 ampere battery field fuse located in the electrical cabinet protects the battery field circuit. If the fuse is blown the locomotive will not develop normal power.

419. AUXILIARY GENERATOR FUSE (BATTERY CHARGING)

This 250 ampere fuse located in the electrical cabinet protects the auxiliary generator against any possible overload. If the auxiliary generator output fuse should become blown it will cut off the auxiliary generator from the low voltage system and alternating current system. The ammeter will indicate a discharge when the auxiliary generator output fuse is blown, the alarm horn will function, and the "Alternator Failure" light will be ON in the unit affected.

420. AUXILIARY GENERATOR FIELD FUSE

This 30-ampere fuses located on distribution panel, Fig. 2-5, protects the auxiliary generator field windings against excessive current. If the fuse is blown the auxiliary generator will not supply current to the low voltage system and the alternating current system. With the auxiliary generator field fuse blowed the battery ammeter will indicate a discharge, the alarm horn will function, and the "Alternator Failure" light will be ON in the unit affected.

421. ALTERNATOR FIELD FUSE

This 60-ampere fuse, located on distribution panel protects the alternator field windings against possible overload. Blowing of this fuse will shut off the supply of AC current to the traction motor blowers and radiator cooling fans. When this fuse is blown, the alarm horn will function and the "Alternator Failure" light will be ON in the unit affected.

422. NO AC VOLTAGE RELAY

As the traction motors are cooled by AC driven blowers, failure of the alternator could result in damage to the traction motors unless the application of power was stopped. Thus, in case of an alternator failure, the NVR, Fig. 2-5, located on the relay panel in the electrical cabinet, drops out and causes the alarm in all units. The "Alternator Failure"

light will be on, and the engine speed reduced to idle in the unit affected (if the throttle was in the 5th or 6th notch the engine would stop). The NVR "dropping out" can be caused by (1) "Auxiliary Generator Field" or "Alternator Field" fuse blown (2) Auxiliary generator fuse blown or (3) Diesel Engine stopped while "on the line".

423. ELECTRICAL CIRCUITRY

To better understand the following information it is suggested that the Legend of Electrical Equipment found at the end of this section be used.

Before going into an explanation of electrical circuits it might be well at this point to explain the operation of relays and contactors as used on the locomotive.

A relay consists of an operating coil and a group of auxiliary contacts called interlocks. The interlocks can be normally open or normally closed when the operating coil is normal. Normal is defined as having the operating coil de-energized, that is to say, there is no current flow to the coil. Energizing the coil will reverse the interlocks, that is, the normally open interlocks will close and the normally closed interlocks will open.

A contactor consists of an operating coil, a set of main contactors and several interlocks, Fig. 4-2. The designation of both the operating coil and the contactors are usually the same. The interlocks are designated by a double letter preceding the names of the coil, for example, AB SF indicates the AB interlock of the shunt field contactor (SF). The term SF would be found on the symbol for the operating coil as well as the main contacts.

The schematic diagrams found in this manual show the various electrical components with regard to their function, rather than their exact location. In this way it is possible to see the sequence of action necessary to complete a circuit and, once one becomes familiar with the wiring diagram and location of the pieces, locate the cause of most of the troubles that might occur.

A physical diagram of the locomotive would then be used to locate the individual terminal or connection where the trouble is located.

The schematic diagram is comprised of all the circuits of the locomotive and it is not the purpose of this manual to discuss them individually. Certain basic circuits necessary to enable the unit to move under power will be discussed.

In tracing circuits it must always be remembered that electricity will flow only when a complete path, or circuit exists. Electrical energy will flow from some source, generator, or battery to a device, relay or contactor, and back to the source. The schematic diagram shows the operating coils tied to a common negative wire thus alleviating tracing the negative return of each individual circuit.

Before actually discussing a particular circuit it would be well to remember that unless otherwise stated the electrical schematic is drawn in the following manner:

1. Wires that cross have no electrical connection unless indicated by a dot at the junction of the lines.
2. All switches are drawn in the "open" or "off" position.
3. All contactors and relays are drawn in the "normal" or de-energized position.
4. In order to permit the flow of electrical energy through a normally open contact or interlock, it is first necessary to close said point by first energizing the proper operating coil.
5. The isolation switch (IS) is always drawn in the "Start" position.
6. Current flow is assumed to be from positive (+) to negative (-).

The circuits discussed in the following articles are found on the locomotive schematic diagram and have been removed only for the sake of simplifying their explanation.

424. FUEL PUMP

To complete the fuel pump circuit shown in Fig. 4-3 it is necessary to close the main battery switch, the control and fuel pump circuit breakers in the electrical cabinet, the control switch on the driver's control panel, and four emergency fuel cutoff switches on either side and in either cab of the locomotive.

Current can then flow from the positive (+) side of the battery through the battery knife switch along the BP wire, through the control and fuel pump circuit breakers and control switch. The current cannot flow to the fuel pump motor because the AB and CD interlocks of the fuel pump contactor (FPC) are open. Thus it is necessary to first establish a circuit to the operating coil of FPC. This is done by following the PC wire past the four closed emergency fuel cut-off switches to the operating coil of FPC, and thence back to the negative side of the battery through the 30-ampere control fuse.

Now that the FPC operating coil is energized, the normally open AB and CD interlocks close permitting current to flow through the closed 15-ampere fuel pump circuit breaker to the fuel pump motor.

In summarizing we can say that the fuel pump motor cannot be energized until the fuel pump contactor is energized.

425. ENGINE STARTING CIRCUIT

In fig. 4-4 the engine starting circuit is shown. It may be assumed, to avoid repetition that the fuel pump is running.

Current will flow from the positive (+) side of the battery along the BP wire through the 30-ampere control circuit breaker and control switch to the PC wire.

When the start button is depressed a circuit is established to the operating coil of the GS contactor through the AB portion of the isolation switch (IS). The main contacts of the starting contactor (GS) will then be closed, permitting current flow from the battery through the 400-ampere starting fuse through the armature and starting field of the main generator. This action will normally cause the generator to rotate the diesel engine at such a speed that ignition will take place and the engine is started.

426. BATTERY CHARGING CIRCUIT

The battery charging circuit, Fig. 4-5, shows how the auxiliary generator output is used to maintain a charge on the locomotive batteries when the engine is running.

Due to the potential difference between the auxiliary generator and the batteries, current will flow from the positive (+) side of the auxiliary generator through the 250-ampere auxiliary generator fuse, through the rectifier thence to the positive side of the battery. The rectifier, that allows the current to flow only in one direction, prevents the current from the battery to rotate the auxiliary generator as a motor, if the voltage of the auxiliary generator for some reason is lower than the voltage of the battery.

427. OPERATING LEVERS

The control levers located on the driver's control stand are the reverse lever and throttle lever. Movement of these handles will open or close switches contained inside the driver's control stand. These switches are shown diagrammatically in Fig. 4-6.

The dots shown below the lever position indicate the switches that are closed for a particular position.

428. DIRECTION CONTROL CIRCUIT

The FO wire is energized when the reverse lever is put in the Forward position establishing a circuit to the operating coil of the forward pilot relay (FOR), Fig. 4-7. This permits a current flow through the normally open AB interlock of the FOR, provided the circuit breaker is closed and the POA wire is energized. A circuit is then established to the operating coils of the reverser forward contactors RVF14 and RVF2. A normally closed GH interlock of the FOR will open to prevent a circuit from being created to the reverserreverse direction contactors RVR5 and RVR36. The energizing of the operating coils of RVF14 and RVF2 will cause the main contacts to close and permit current to flow from the main generator through the field windings of the traction motors in the proper direction.

If the reverse lever were placed in the Reverse position, the pilot relay RER would be energized along with the operating coils of contactors RVR5 and RVR36. This would create a circuit changing the direction of current flow through the traction motor fields, consequently changing the direction of their rotation and the direction of locomotive movement.

429. POWER CONTACTOR CONTROL CIRCUIT (Fig. 4-8)

The operating coils of S45 and S23 power contactors are simultaneously energized from the previously energized POA wire provided the isolation switch (IS) has been put in the RUN position. The path for the current is through the now closed EF interlock of FOR, and the EF interlocks of RVF2 and RVF14. See previous circuit, the GH portion of IS and the normally closed AB interlock of GS.

The circuit to S45 and S23 operating coils is then completed through the normally closed interlocks AB of P25 contactor.

430. EXCITATION CIRCUIT (Fig. 4-9)

When the power contactor operating coils for S45 and S23 are energized the normally open interlock EF of S45 closes. This will permit current to flow from the GF wire through the isolation switch (IS) (now closed in RUN position) and thus to the operating coil of the shunt field contactor (SF). With the SF coil energized, its normally open AB interlock will close establishing a circuit to the operating coil of the battery field contactor (BF). This closes the main battery field contacts (not shown) permitting current to flow and excite the battery field windings of the main generator, causing it to generate electrical power.

431. ENGINE SPEED CONTROL

The throttle lever in the controller, has ten positions: STOP, IDLE, and Running Speeds 1 through 8. Each throttle step from 2 through 8 increases the engine speed 80 RPM as can be seen from the engine speed chart.

Movement of the throttle lever operates a cam that will cause the roller type throttle switches to be opened or closed in various combinations, depending on throttle position.

Throttle Position	Governor Solenoids Energized				Engine Speed RPM
	A	B	C	D	
STOP				x	0
IDLE					275
1					275
2	x				355
3			x		435
4	x		x		515
5		x	x	x	595
6	x	x	x	x	675
7		x	x		755
8	x	x	x		835

Governor Solenoids Energized

	A	B	C	D
Effect of Solenoids on Engine RPM	+80	+320	+160	-160 (or stop)
Engine Speed Chart				

The governor is designed so that energizing various solenoids, or combinations of the four governor solenoids (AV, BV, CV and DV) causes the engine to respond to the position of the throttle lever. Fig. 4-10 shows the method of energizing the governor solenoids for the different positions of the throttle lever.

432. ENGINE LOAD CONTROL

The horsepower output of the diesel engine is determined by its rate of fuel consumption; this means that if more horsepower is needed, more fuel must be used. When the engine is loaded there is a definite rate of fuel consumption or horsepower produced for each throttle position. The governor, in order to maintain a constant speed for each throttle position, must increase or decrease the load so that the rate of fuel consumption is correct to obtain the required horsepower for that throttle position. The engine load is adjusted by the governor through the action of its load regulator pilot valve which controls the position of the load regulator rheostat. The load regulator thus adjusts the strength of the main generator battery field and consequently the output of the main generator and the engine.

If the engine requires more fuel to maintain the given engine speed than the predetermined setting (or pilot valve balance point), the load regulator brush arm is automatically moved to reduce the battery field strength of the main generator thereby reducing the load on the engine.

Conversely, if the engine requires less fuel to maintain the given engine speed than the predetermined setting, the load regulator is moved to increase the battery field strength, thereby increasing the load on the engine.

433. LOAD REGULATOR

Essentially the load regulator is a mechanically operated rheostat which is connected in series with the battery field of the main generator. The load regulator is a self-contained unit which consists of a hydraulic vane type motor connected by a common shaft, to the movable brush arm of a commutator type rheostat. Engine oil pressure is used to move the vane motor (and rheostat brush arm) to change its position. Oil pressure is admitted to either side of the vane, as directed by the load regulator pilot valve, which is located in the engine governor assembly.

Also in the governor assembly is an overriding solenoid, ORS, which will override the normal action of the load regulator pilot valve, under certain

conditions. When the ORS is energized the load regulator pilot valve is moved in such a manner that engine lubricating oil will move the load regulator to the minimum field position. Let us say, for the sake of discussion, minimum field is the same as minimum main generator voltage. It can, therefore, be said that energizing ORS unloads the engine. The ORS is energized during one step of transition (series-parallel to parallel).

434. WHEEL SLIP CONTROL

The wheel slip control system goes into operation the moment that the slipping of a pair of wheels is detected while under power. Located in the electrical cabinet are 5 wheel slip control relays, WCR, WSS, WS5, WS14 and WS36.

The WCR (wheel creep relay) and WSS (wheel slip series) are operated by a current differential between the cables that pass through the relay frame.

These cables are so arranged that the normal current flow through them is of equal magnitude and in opposite directions. Thus the magnetic field established by the current flow in one cable is nullified by the magnetic field established by the current flow in the second cable. When an unbalance in the current flow occurs as a result of a "slipping" motor, the resulting magnetic field thus established actuates the wheel slip relay.

Automatic sanding in power occurs through the action of the WCR relay. The WCR is used to detect very slow creeping type slips. The function of the WCR, having a slightly lower pickup value than the WSS, is to automatically apply sand to the rails which tends to prevent a wheel slippage necessitating the reduction of generator field excitation.

When WCR picks up, it energizes the time delay sanding relay (TDS). "Picking up" of the TDS automatically actuates the forward or reverse sanding valves, depending on the position of the reverse lever, applying sand to the rail.

A very slow speeds, if the wheel slip cannot be corrected through the action of the WCR applying sand to the rails, the WSS picks up to reduce main generator excitation. When the WSS picks up, the wheel slip light will flash ON and the battery field contactor (BF) will open. Opening the battery field contactor "cuts out" the main generator battery field excitation and causes the overriding solenoid (ORS) to move the load regulator toward the minimum field position. This action will generally correct the wheel slip, and it should not be necessary for the engineman to reduce the throttle. The function of the WSS relay is to recognize slow speed wheel slips and effect a slip correction with a minimum loss of tractive effort.

If further reduction of main generator excitation is necessary to correct wheel slip, one of the WS 5, WS 14 or WS 36 relay will pick up.

The WS 5, WS 14 and WS 36 relays are operated by a flow of current through the relay coil. Current will flow through the relay coil when an unbalance in the bridge circuit between two 2000 ohm resistors and two traction motors, which the relay coil bridges, occurs as a result of a "slipping" motor.

When a WS relay picks up, the wheel slip light at the drivers control stand will flash ON and the shunt field contactor (SF) will open. The normally open AB interlock of SF will then be opened causing the battery field contactor (BF) to open. The opening of the contactors cuts off the main generator excitation and causes the overriding solenoid (ORS) in the engine speed governor to become energized. This action, in turn, causes the load regulator to move toward the minimum field, or minimum excitation position. Thus, with the power reduced the slipping will stop and the wheel slip relay will drop out. Power is automatically reapplied at a lower level than that at which the slipping occurred. The application of power will then gradually return to the amount determined by the position of the throttle lever. This action will, generally, correct the wheel slip action and it should not be necessary for the driver to reduce the throttle.

Since sand is automatically applied to the rails during a wheel slip detection, it should be unnecessary for the engineman to operate the manual sanders. If continuous wheel slipping on sand occurs, the throttle should be reduced.

435. AUTOMATIC TRANSITION

The term "transition" is applied to the changing of connections between the traction motors and the main generator in order that full power may be obtained from the main generator, within its current and voltage limits.

On a diesel-electric locomotive the maximum permissible speed is determined by the maximum safe rotational speed of the traction motor armature; minimum continuous speed by the maximum amount of amperage that the electrical equipment can withstand without damage. In order to obtain the full power available between these extremes, automatic transition is necessary.

Automatic transition may be looked at in yet another way. It is the means of overcoming the counteremf (CEMF) generated by the traction motors. This CEMF or "back pressure" must be adjusted such that it will not be too high at the higher speeds or too low at lower speeds.

At rest, the traction motor armatures have practically no resistance to the input of main generator current. However, as the locomotive speed increases the CEMF of the traction motors also increases, forcing the main generator voltage even higher, to overcome this effect in order to supply current to the motors. This effect will continue throughout the operating range of the main generator. If the practical voltage limit of the main generator were to be exceeded the power output of the main generator and of the engine would be reduced. To prevent this loss of power a circuit change is made between the traction motors and main generator to preclude this loss of efficiency.

As locomotive controls are set up for operation, S23 and S45 contactors are energized to automatically connect the traction motors in two groups of three motors in series, each group paralleled across the main generator, thus establishing transition step one, see Fig. 4-11. As locomotive speed increases, in step one, the main generator voltage reaches the point where it will pick up PTR, FSR1 and RT relays, which in turn drop out SF and BF relays. As main generator voltage drops off or decays, FSR1 drops out to allow P25 contactor to pick up. As P25 picks

up, S45 and S23 drop out, P36 and P14 pick up. P25 and P14 closing pick up SF and BF. Main generator voltage will now build up and locomotive speed will increase with the traction motor now connected as shown in Fig. 4-12, to establish the second step in transition.

As the locomotive continues to build up speed, the previously described build up of CEMF and main generator voltage is repeated, and again the circuits are changed to prevent a drop in power. This time a bypass (shunt) circuit is established around the field of each traction motor by closing FS1 contactor, as seen in Fig. 4-13, and thus establishes the third step of transition. Shunting of the fields of the traction motors will reduce the CEMF, which in turn, reduces the voltage output of the main generator.

As locomotive speed continues to build up, CEMF and main generator voltage again increases and it is necessary to establish a second step of field shunting and bring in FS2 contactors, see Fig. 4-14, in order to maintain full power output on the locomotive.

As speed is reduced, the generator voltage drops, allowing FSR1 to drop out and step back from 4 to 3; FSR1 steps back from 3 to 2 and PTR from 2 to 1. The locomotive is now in a slow speed heavy pulling circuit with the generator protected for such service.

At any time during locomotive operation the transition control system will automatically cause progressive steps forward or backward as required, depending on the speed of the locomotive.

GLOSSARY

Ampere	rate of electrical flow.
Armature	the rotating portion of DC generator or motor. Movable part of a relay or contactor.
Battery	a chemical device for storing electrical energy.
Brushes	a carbon block with or without a shunt used to provide a contacting surface for carrying an electrical current from a stationary to a moving surface with a minimum amount of friction.
Circuit	path along which electrical energy may flow from its source back to its source.
Circuit Breaker	a switch, so designed as to open the circuit when the current flow exceeds a predetermined maximum, thereby protecting equipment in the circuit concerned.
Commutator	an assembly of copper segments, separated by insulators, to which the ends of the armature windings are attached.
Conductor	any material which will readily permit the flow of electrical energy.
Contactor	device used to establish or interrupt a circuit depending upon whether its operating coil is energized or de-energized.
Dielelectric	name applied to ability of material to pass current. High dielectric strength denotes insulation; low indicates a conductor.
Direct Current (DC)	an electrical current which flows in one direction only.
Electromotive Force (emf)	electrical pressure expressed in volts.
Excitation	the current flow through field windings to create magnetism which is cut by the rotating armature to generate electricity.

Field Coil	windings placed upon the field poles of a motor or generator to conduct the electrical current which creates the magnetic field.
Fuse	a wire or strip of metal enclosed in a container, which when inserted into a circuit will interrupt current flow at a predetermined value.
Insulator	material that will not readily conduct an electrical current. Material having high dielectric strength.
Interlock	an auxiliary switch actuated by a contactor or relay to make or break electrical circuits.
Jumper Cable	a flexible cable containing several conductors to establish circuits between units for multiple unit operation.
Magnet	any object having the property of magnetism.
Magnetic Field	term used to describe the magnetic effect created when the field coils are excited.
Magnetism	having the property of attracting iron and generating an electrical current when cut by a conductor.
Ohm	unit of resistance to electrical flow.
Pole Pieces	that portion of the electrical device around which field coils are wound.
Relay	an electrical device which establishes circuits to control the operation of other electrical equipment.
Resistance	term used to describe opposition to current.
Rheostat	a variable resistance.
Selenium Rectifier	a device having the property of permitting a current flow in one direction only.
Shunt	an electrical by-pass.

Solenoid	a coil used to produce a magnetic field and impart motion to an armature.
Switch	a manually operated device used to establish or interrupt a circuit.
Terminal Board	panel used to interconnect circuits.
Transition	term used to describe the automatic changing of connections between traction motor and the main generator.
Volt	unit of electrical pressure sometimes called potential, potential difference, or emf.
Watt	unit of electrical power. Product of volts times amperes.

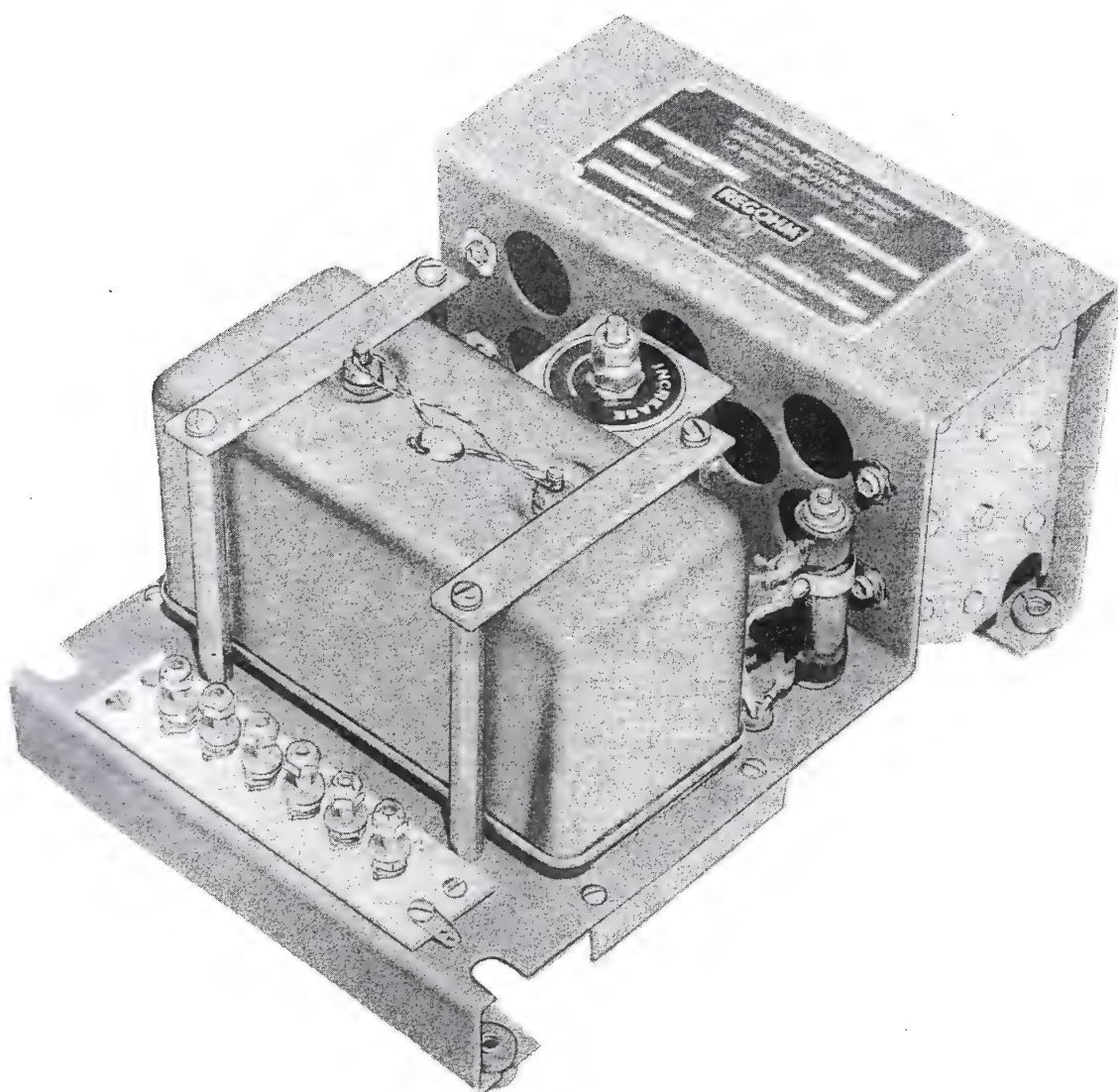
LEGEND OF ELECTRICAL EQUIPMENT

The following list shows abbreviations identifying electrical equipment on the locomotive and the wiring diagram. The diagram wire designations conform with the identification bands on the wires in the locomotive.

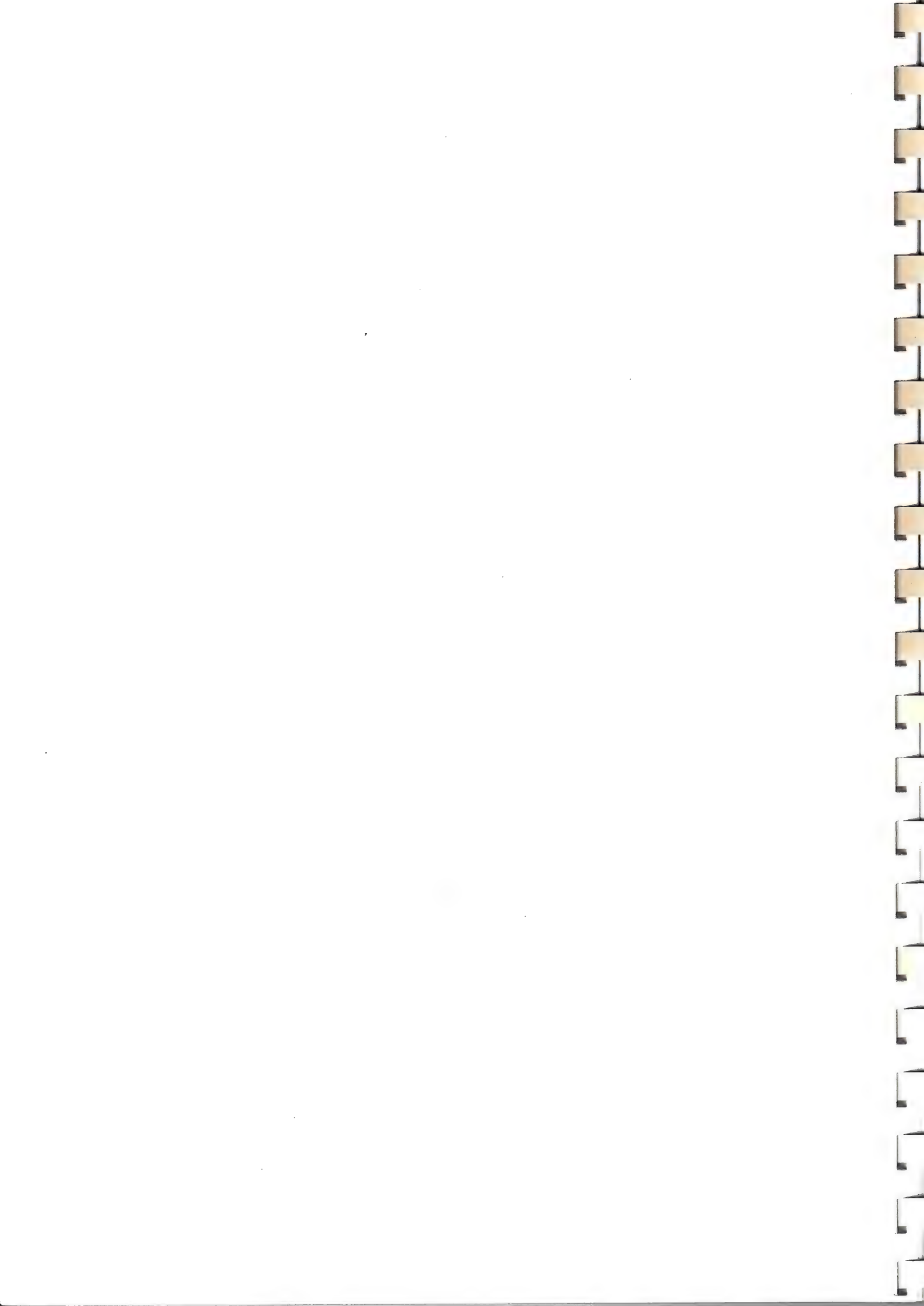
The diagram shows the contactors, switches and relays as if the engine were stopped and all manual switches open. It must be remembered that when the operating coil of a contactor becomes energized the contacts and interlocks associated with that contactor will then be in a position opposite to that shown on the locomotive wiring diagram.

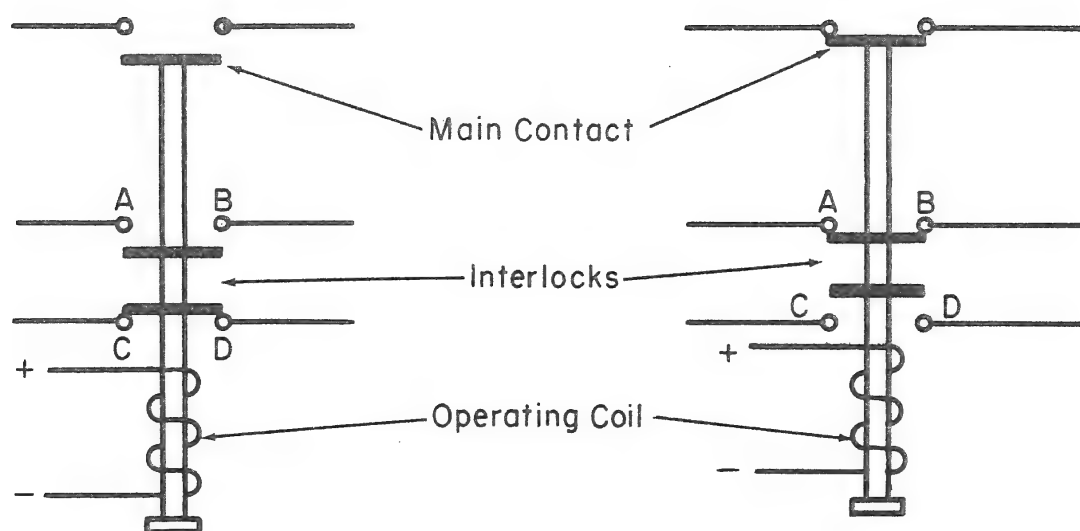
A	Battery Charging Ammeter and Traction Motor Ammeter
AC 1-4	AC-Contactor for Cooling Fans
AV	Governor "A" Solenoid
AGP	Auxiliary Generator Positive
BA	Boiler Alarm
BF	Battery Field Contactor
BTN	Battery Negative
BTP	Battery Positive
BV	Governor "B" Solenoid
CV	Governor "C" Solenoid
DIFF	Differential Field
DV	Governor "D" Solenoid
ER	Engine Relay (ER Relay)
ETS	Engine High Temperature Switch
FOR	Forward Direction Pilot Relay
FPC	Fuel Pump Control Relay
FSD	Field Shunting Delay Relay
FS1, FS2	Traction Motor Field Shunting Contactors
FSR1, FSR2	Field Shunting Relay
FSV	Forward Sanding Magnet Valve
GN	Main Generator Negative
GP	Main Generator Positive
GR	Ground Relay
GS	Generator Start Contactor
IS	Isolation Switch
LOS	Low Oil Pressure Switch
N	Negative
NVR	No Voltage Relay
ORS	Governor Overriding Solenoid

PCR	Pneumatic Control Relay
PL	Positive Lights
PC, POA	Positive Control
P14, P25, P36	Parallel Contactor
RER	Reverse Direction Pilot Relay
RSV	Reverse Sanding Magnet Valve
RVF2, RVF14	Magnet Switchgear - Forward
RVR5, RVR36	Magnet Switchgear - Reverse
S23, S45	Series Contactor
SF	Shunt Field Contactor
SV	Steam Generator Blowdown Valve
SMV	Shutter Magnet Valve
TA, TB	Temperatur Control Switches
TC TD	
TDS	Time Delay Sanding Relay
TR	Transition Relay
WCR	Wheel Creep Relay
WSS	Wheel Slip Series Relay
WS5, WS14	Wheel Slip Relay
WS36	



Voltage Regulator



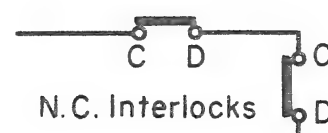
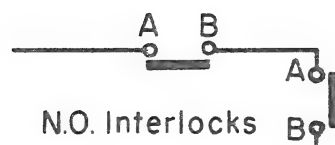


No Power To Coil

Main contact normally open
 Interlock AB normally open
 Interlock CD normally closed

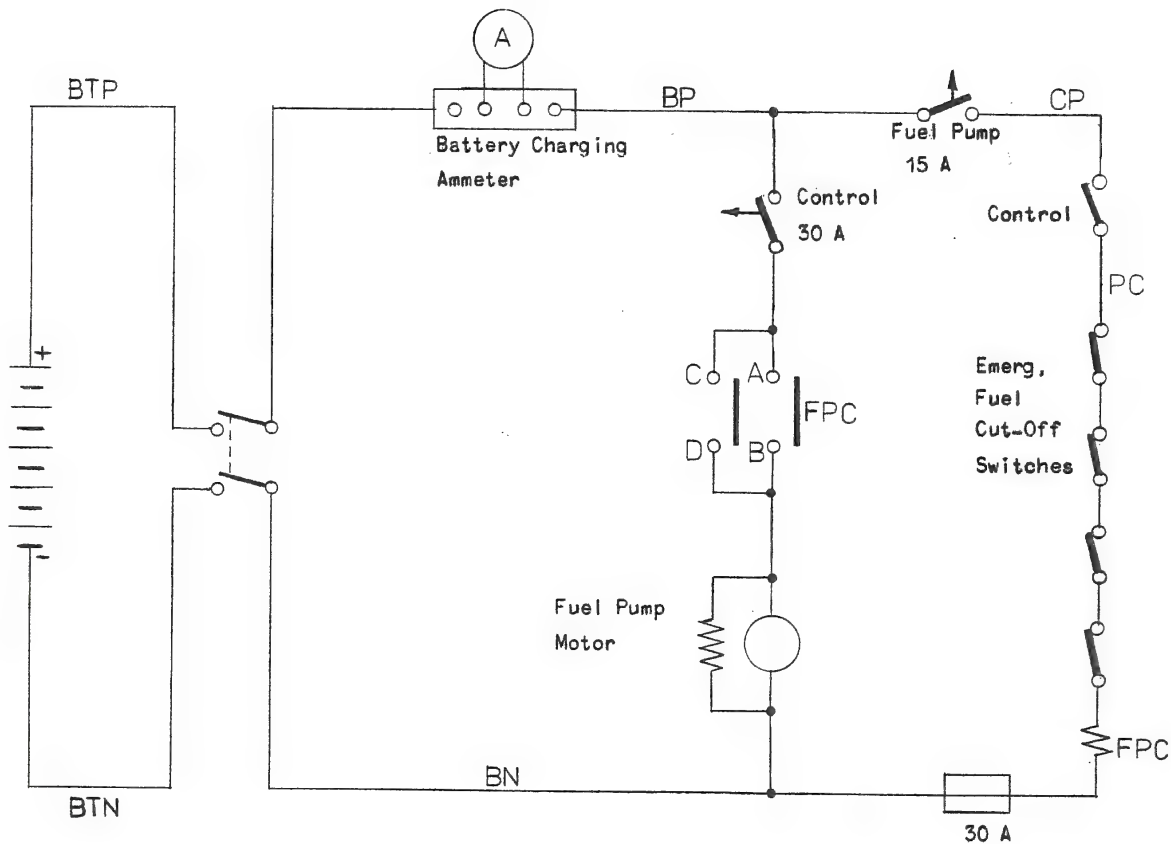
Power Applied To Coil

Main contact now closed
 Normally open AB interlock
 now closed
 Normally closed CD interlock
 now open



Shown schematically on a wiring diagram, the normally open (N.O.) interlock is either below a horizontal line or to the right of a vertical line. The normally closed (N.C.) interlock is shown above or to the left side of a line.

Contact And Interlock Operation



Fuel Pump Circuit

Fig. 4-4

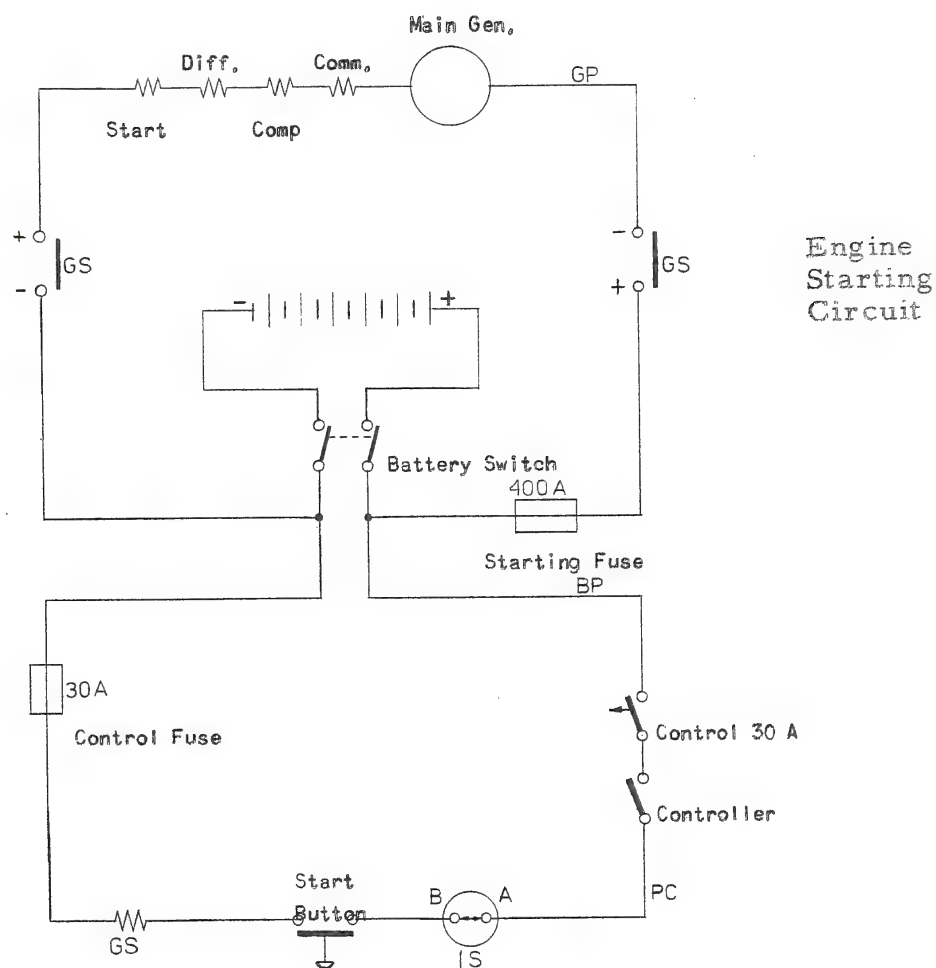
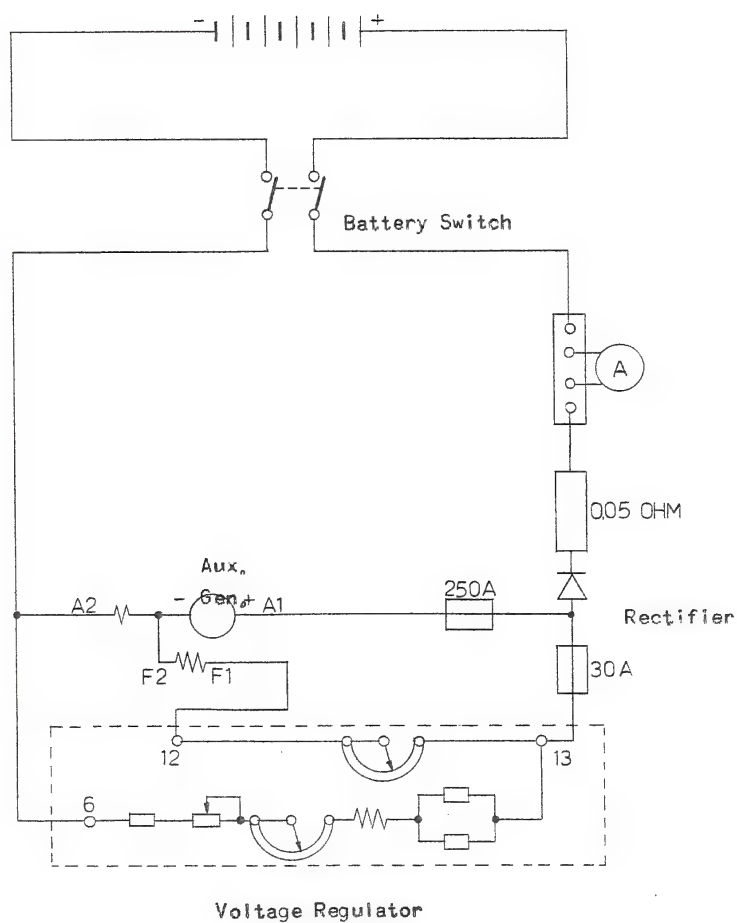
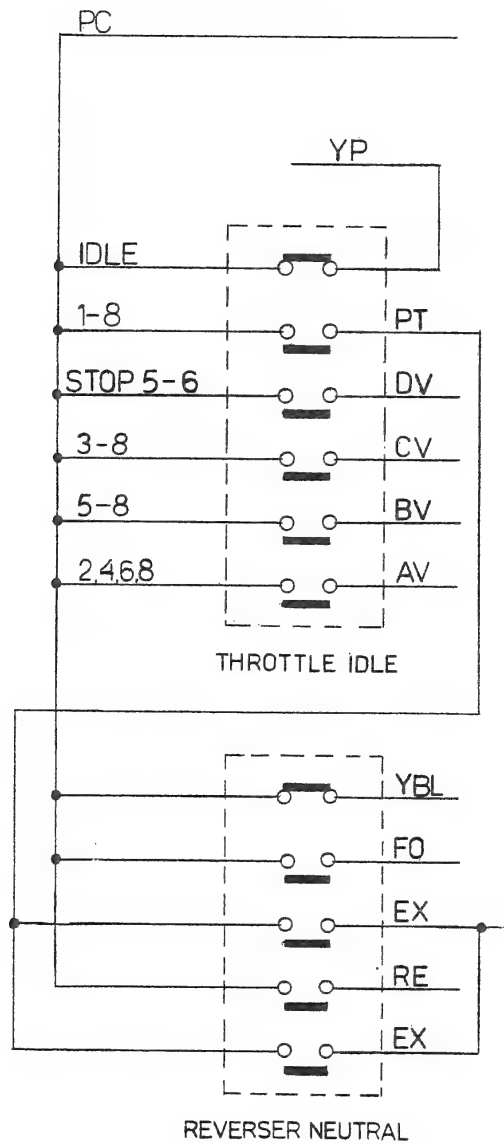


Fig. 4-5





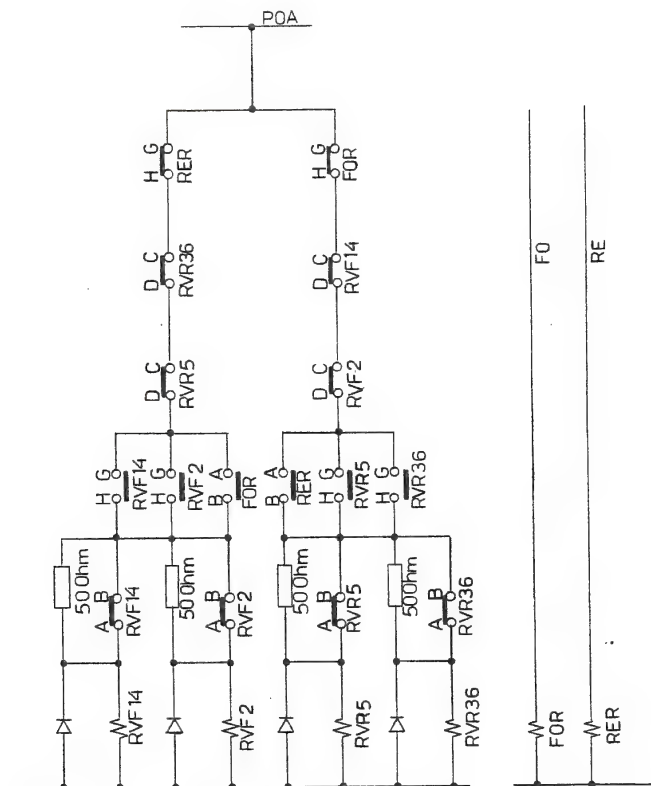
		POSITION							
STOP	IDLE	1	2	3	4	5	6	7	8
	○								
		○	○	○	○	○	○	○	
○						○	○		
				○	○	○	○	○	○
						○	○	○	○
		○		○		○		○	

THROTTLE HANDLE
SHOWN IN IDLE POSITION

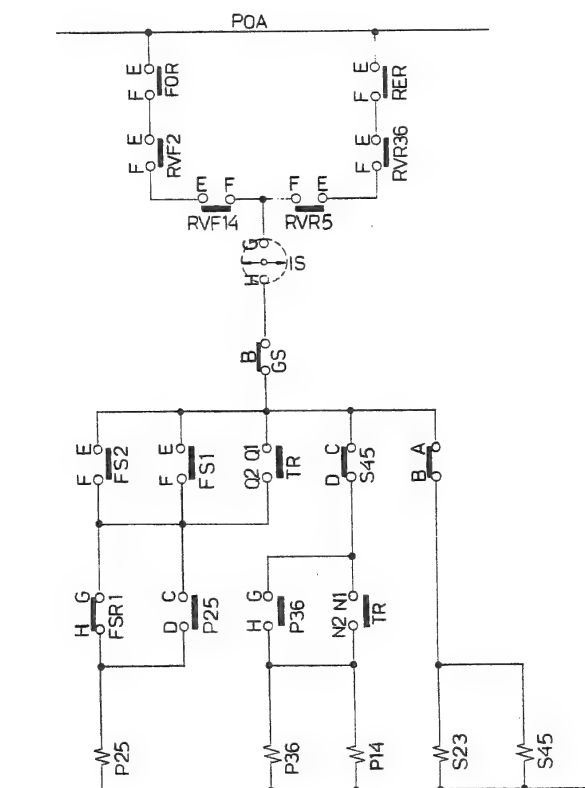
		POS	
REV	NEUTR	FOR	
	○		
		○	
		○	
○			
○			

REVERSING
HANDLE SHOWN IN NEUTR.
POSITION

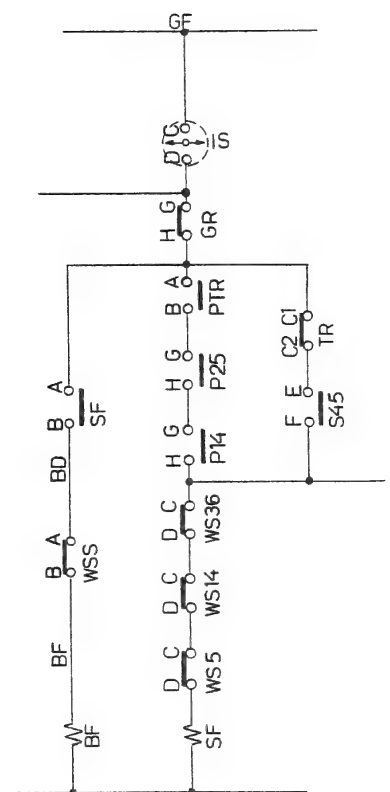
Schematic Of Control Levers



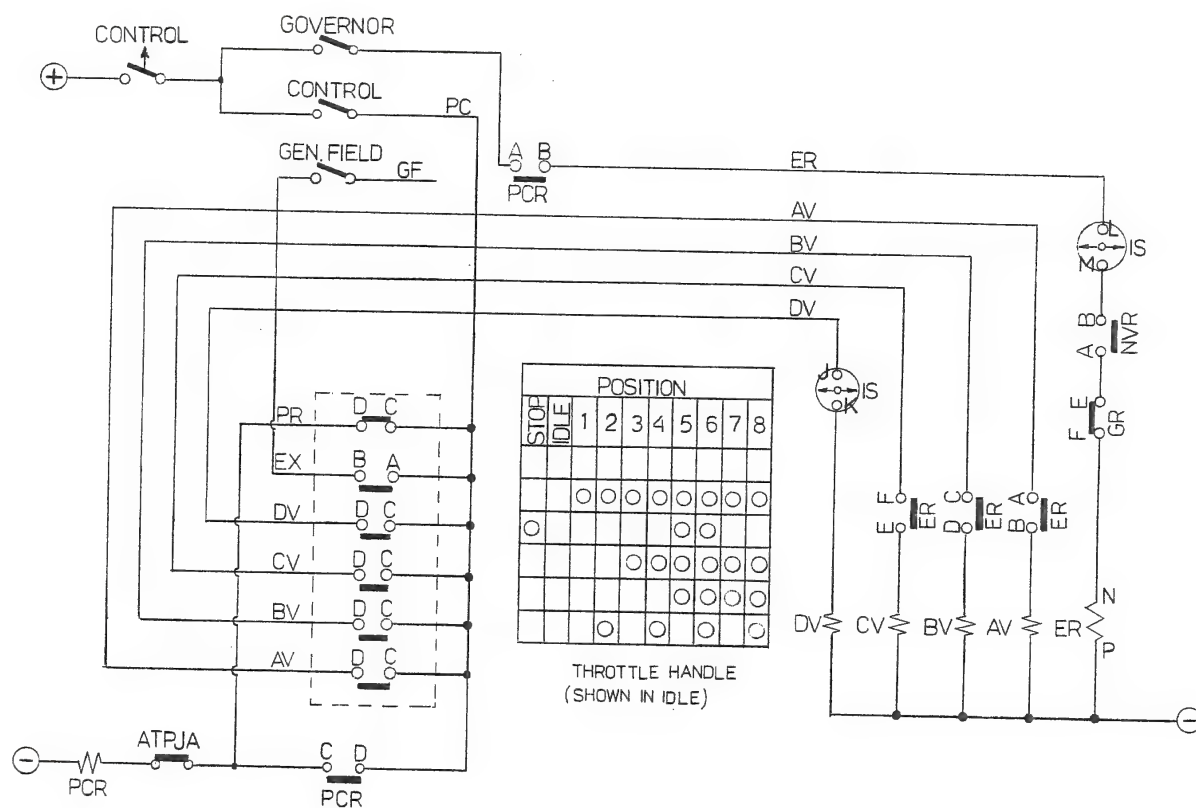
Direction Control Circuit
Fig. 4-7



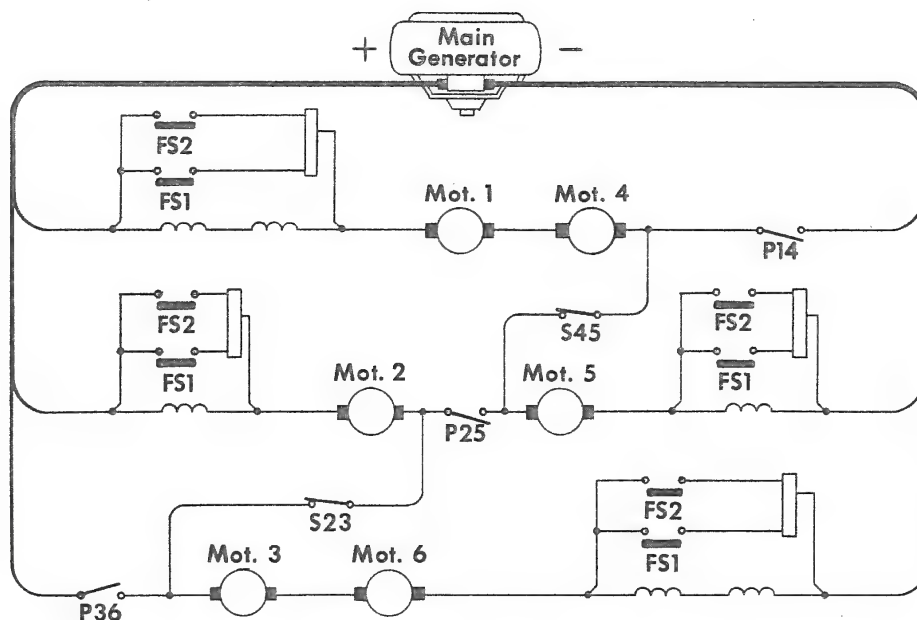
Power Contactor Control Circuit
Fig. 4-8



Excitation Control Circuit
Fig. 4-9



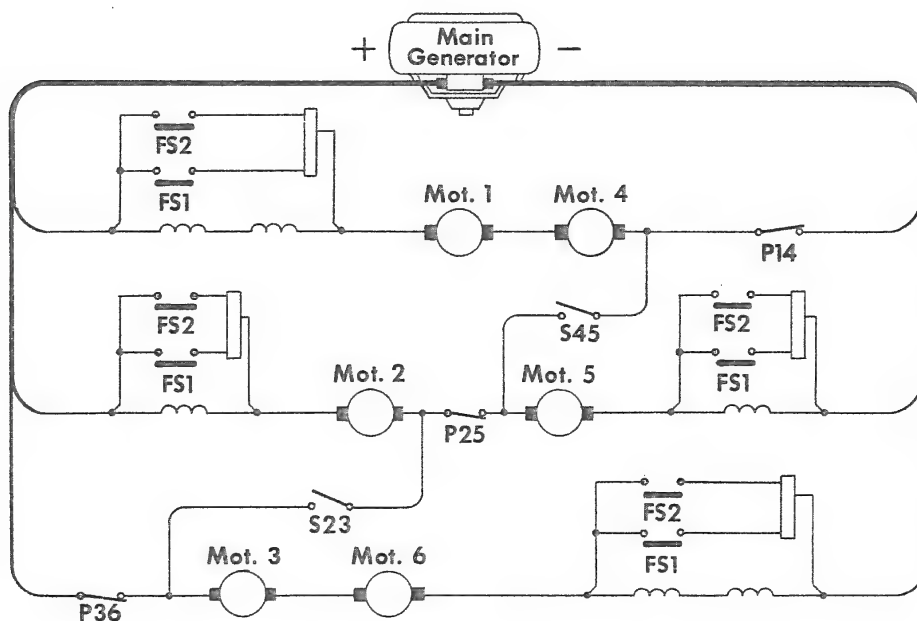
Engine Speed Control Schematic Diagram



Transition Step 1

Two Groups Of Three Motors Connected In Series
Each Group Then Paralleled Across The Main Generator
(S23 And S45 Closed)

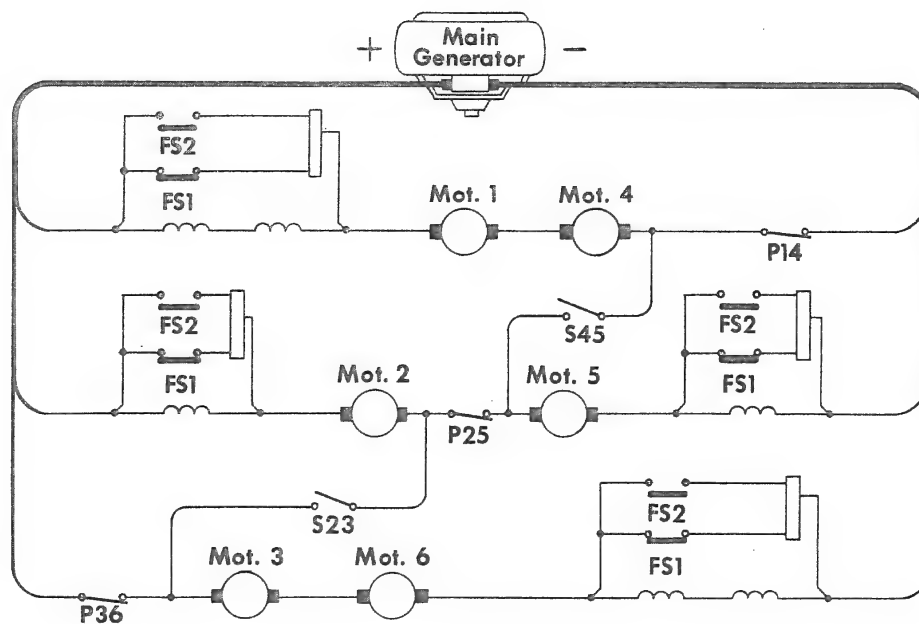
Fig. 4-12



Transition Step 2

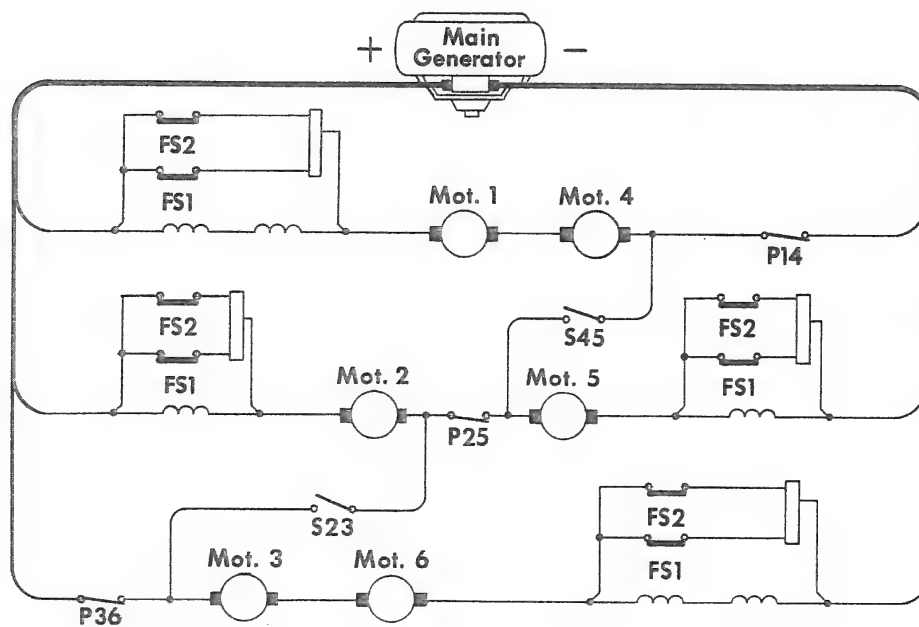
Three Groups Of Two Motors Connected In Series
Each Group Then Paralleled Across The Main Generator
(P14, P25 And P36 Closed)

Fig. 4-13



Transition Step 3
Same Motor Hookup As Step 2
With FS1 Shunt Picked Up

Fig. 4-14



Transition Step 4
Same Motor Hookup As Step 2
With FS1 And FS2 Picked Up

SECTION 5

LOCATION AND CORRECTION OF DIFFICULTIES ON-THE-ROAD

This section provides a check list calling the operator's attention to the troubles which are most frequently encountered on the road, and which can be quickly remedied, thereby eliminating many delays.

No attempt is made to explain general operation and functions of equipment on the locomotive. For such information, refer to other sections of this manual.

500: GENERAL

Many safety devices will automatically protect the equipment in case of faulty operation of most components. In general, this protection is obtained by unloading or preventing the loading of the diesel engine so that the locomotive loses its pulling power. The locomotive can lose its power with the diesel engine continuing to run or by shutting it down. An exception is a hot engine alarm which does not reduce the generator load or engine speed. The trouble locating check chart at the end of this section outlines the possible causes of trouble should the locomotive suddenly lose its power, either with the diesel engine running or stopped.

When trouble is experienced, the general location and type of difficulty is often indicated by sounds an alarm horn and lighting one or more signal lights in the affected unit.

The lights listed below are located on the driver's control panel shown in Fig. 2-4, and are identified by badge plates.

1. Hot Engine - Indicates at 98°C and goes off at 94°C .
2. Ground Relay - Indicates passage of current to ground.
3. PC Switch open
Power control - open $1,2\text{ kg/cm}^2$
close $1,0\text{ kg/cm}^2$.
4. Wheel Slip- Indicates one pair of wheels slipping.
5. Steam boiler stopped.
6. Alternator failure (No AC power).

The lighting of either the hot engine or the ground relay indicating light is accompanied by the sounding of the alarm. The alarm horn also sounds in case of low oil pressure but does not show a light indication. The wheel slip light will show only to indicate locomotive operational exigencies. However, a continuous wheel slip light could mean that a pair of wheels has locked. Should this occur, stop the train, and start it again slowly while someone on the ground ascertains that all wheels are turning properly. If ANY wheels are locked, DO NOT MOVE LOCOMOTIVE.

All of the circuit breaker type switches located on the electrical cabinet, Fig. 2-5c, are of 30 ampere capacity except the fuel pump which are rated at 15 amperes. The circuit breaker switches are on (closed) when in the UP position; off (open) when DOWN.

If a circuit breaker is overloaded and trips open, service may be restored by first placing switch fully OFF, and then moving it to ON.

501. IF ALARM HORN SOUNDS

There are two lights either or both of which may show in the cab of the affected unit to identify the cause of the alarm. These are the ground relay light and the hot engine alarm light. In a multiple unit locomotive the alarm horn will sound in all units, but the indicating light will show only in the affected unit.

GROUND RELAY

Whenever the ground relay trips, the locomotive loses its power, and reduces the speed of the diesel engine to IDLE.

If the throttle is allowed to remain in Run 5 or 6, after the ground relay trips, the engine will stop.

To reset a tripped ground relay, isolate the engine, place the throttle in IDLE, and move ground relay reset button to RESET position. After resetting the relay, place the engine on-the-line (isolation switch in RUN). If the ground relay continues to trip, reset to silence the alarm horn and leave the engine isolated (isolation switch in START). Instructions from the mechanical officer should govern operation under these conditions.

HOT ENGINE

This light indicates that the engine water temperature is above that recommended for safe operation 94 - 98° C. A hot engine alarm does not stop the engine or reduce the speed or power output. The alarm horn will silence when the temperature becomes normal.
To correct:

1. See that the control and fuel pump switches are ON.
2. See that the cooling water level is correct, Fig. 3-6.
3. See that the valve in the air supply pipe to the shutter magnet valves and the fan magnet valve are open.
4. See that the contactors for the radiator fans are closed.

If the cause for the hot engine alarm cannot be quickly determined, isolate the engine and investigate. If there is a sufficient amount of water in the system, allow the engine to run at idle speed. The water temperature should soon become normal and the alarm horn will silence. The hot engine alarm will silence when the engine water temperature falls to 94° C.

LOW OIL PRESSURE

If the alarm horn sounds without any light indication, the reason may possibly be low oil pressure. In this case the affected engine will stop and the governor low oil pressure button will move out exposing the red band around the plunger.

To reset, push in the low oil reset button on the governor. Check the engine oil level and if within limits start the engine and check the lubricating oil pressure. Do not repeatedly start engine if the LOW OIL button continues to shut the engine down.

ADDITIONAL SAFETY DEVICES

502. ENGINE OVERSPEED TRIP

If the engine speed should exceed 910 RPM, an overspeed device, Fig 3-5, located on the front end of the engine will trip and stop the engine by preventing the injectors from pumping fuel into the cylinders. The overspeed trip must be manually latched in the set position before the engine can be started.

503. FUEL FLOW

For proper operation a good flow of fuel, clear and free of air bubbles, should be visible in the fuel return sight glass, located on the engine mounted filter assembly, Fig. 2-9.

If fuel is not flowing through the return sight glass check the fuel pump motor. If motor is not running, check the following:

1. Control and fuel pump circuit breakers in electrical must be ON.
2. Control switch at driver's control panel must be ON.
3. Main battery switch must be closed.
4. The four emergency fuel cut-off switches must be ON.
5. Check for loose cable connections to motor. If the pump is running, but fuel is not flowing, check:
 - a. Fuel supply.
 - b. A suction leak in the piping, which would be indicated by air bubbles in the return fuel sight glass.
 - c. Suction side of fuel strainer clogged.
 - d. A slipping or broken flexible coupling between fuel pump and motor.

504. EMERGENCY FUEL CUT - OFF SWITCHES

Breaking either of the emergency fuel cut-off switches will stop the fuel pump motor (they are located on each side of the locomotive near the fuel tank filler cap and on each frontwall in both cabs). Fig. 3-11.

CAUTION:

Should the fuel pump stop and difficulty be experienced in starting it, the engine should be shut down manually rather than be allowed to starve for lack of fuel.

505. "PC" SWITCH OPEN

The PC switch open light must be OFF to signify that the PC switch is set. If the PC switch is tripped the indicator light on the driver's control panel will show but the alarm horn will not sound. When the PC switch trips, the power output is interrupted and engine speed is reduced to IDLE in all units in the locomotive consist. The engine will stop if the throttle is in RUN 5 or 6 with the PC switch tripped.

To reset the PC switch:

1. Place throttle in IDLE.
2. Place automatic brake handle in the release and charging position.
3. Depress safety foot pedal or place the reverse lever in neutral position.
4. Wait until application pipe pressure becomes normal. The PC switch is set when the light goes out.
5. Place the automatic brake valve in the RELEASE or RUNNING position.

506. IF THE ENGINE GOES TO IDLE

1. Ground relay may be tripped.
2. PC switch may be tripped.
3. Control switch at driver's control panel may be off.
4. Governor switch at driver's control panel may be off.
5. Isolation switch may be in START position.

507. IF ENGINE STOPS

1. Throttle may be in STOP position.
2. Low oil pressure button on governor may be out.
3. Engine overspeed may be tripped.
4. Ground relay may have tripped with throttle in RUN 5 or 6.
5. PC switch may have tripped with throttle in RUN 5 or 6.
6. Fuel pump circuit breaker in the electrical cabinet may be off.
7. Control circuit breaker in the electrical cabinet may be off.
8. One of the emergency fuel cut-off switches may be in OFF position.

9. Governor switch on driver's control panel may have been moved to OFF position with throttle in RUN 5 or 6.
10. Fuel supply may be depleted.
11. No AC power.

508. TO START ENGINE

1. Place the throttle in IDLE and the reverse lever in NEUTRAL.
2. Place the isolation switch in START position.
3. Place the control, fuel pump circuit breakers in ON position.
4. Close the knife switch in the electrical cabinet.
5. At the driver's control panel, place the control switch in ON position.
6. After allowing a few seconds for fuel to flow through the return sight glass, Fig. 2-9., press the START button and hold solidly until the engine starts. If engine fails to start after 15 seconds of rotation, check for possible troubles as listed under Arts. 509 and 510 before again attempting to start engine.
7. After allowing time for the lube oil pressure to build up, place the isolation switch in RUN position.
8. Place the governor switch at driver's control panel in ON position.

509. IF THE ENGINE DOES NOT ROTATE WHEN THE "START" BUTTON IS PRESSED.

1. See that the control switch at the driver's control panel is ON.
2. See that the isolation switch on the engine control panel is in START position.
3. The control circuit breaker in the electrical cabinet must be ON.
4. The main battery switch in the electrical cabinet must be closed.
5. Check the 400-ampere starting fuse in the electrical cabinet.
6. Check the 30-ampere control fuse in the electrical cabinet.

510. IF THE ENGINE ROTATES BUT DOES NOT START WHEN "START" BUTTON IS PRESSED

1. Low oil pressure button on the governor must be IN.
2. Engine overspeed trip must be SET.
3. Fuel pump circuit breaker must be ON.
4. Emergency fuel cut-off switches must be ON.
5. See that fuel oil supply is adequate.
6. Throttle lever may be in Emergency Stop position.
7. Low oil in governor.

511. IF ENGINE DOES NOT SPEED UP WHEN THROTTLE IS OPENED

1. Engine governor switch on the driver's control panel must be ON.
2. Isolation switch on engine control panel must be in RUN position.
3. PC switch must not be tripped.
4. Ground relay must not be tripped.
5. Control circuit breaker in the electrical cabinet must be ON.
6. 30-ampere control fuse in electrical cabinet should be checked.
7. Fuel pump circuit breaker in the electrical cabinet must be ON.

512. ENGINE SPEEDS UP BUT LOCOMOTIVE DOES NOT MOVE WHEN THROTTLE IS OPENED:

1. Reverse lever must be in either FORWARD or REVERSE position.
2. Generator field switch on the driver's control panel must be ON.
3. Hand brakes and air brakes must be released.
4. 80-ampere battery field fuse must be good.

513. BATTERY AMMETER SHOWS DISCHARGE

1. 250-ampere auxiliary generator (battery charging) fuse must be good.
2. The 30-ampere auxiliary generator field fuse must be good.

514. COMPRESSOR CONTROL

The air compressor is automatically governed and will keep the main reservoir pressure at 11 kg/cm². In case of trouble, the normal position of loader and unloader valves may be changed to manually load or unload the air compressor.

515. CYLINDER TEST VALVES

Each cylinder is equipped with a test valve, Fig. 2-8, to facilitate maintenance. The valves may be opened to relieve compression, thus reducing the effort required to rotate the crankshaft.

If the engine is running and any cylinder test valve is leaking, the engine should be stopped, and the valve(s) tightened. The hot gases blowing by a test valve seal will soon burn the valve seat and make it necessary to replace the entire assembly.

SECTION 6

STEAM GENERATOR

OK - 4616

INTRODUCTION

The instructions contained in this section are for the guidance of personnel engaged in the operation of the steam generator. A general description of the steam generator is given, the operating technique is outlined and a trouble shooting section is provided for the operator.

The symbol number after each device mentioned in the text refers to the schematic operating chart at the end of this section. The numbers are used to facilitate identification of the various devices.

The chart shows the various controls and devices on the OK series of steam generators and outlines the flow of fuel, water and steam.

DESCRIPTION

Steam generators OK 4616 have a rated evaporative capacity of 1600 pounds per hour. Operation is completely automatic after the steam generator is started, and full operating steam pressure is reached within a few minutes.

The steam generating part of the unit consists of three sets of coiled water tubing, nested and connected in series to form a single tube more than hundred meters long. Water is pumped into the coil inlet and converted to steam as it progresses through the coils. Heat is furnished by the combustion of diesel fuel oil, which is sprayed by compressed air through the atomizing nozzle in the fuel spray head-105 into the firepot above the coils. Here the fine oil spray mixes with air supplied by the blower-202, and is ignited by a continuous electric spark-220. The fire and hot gases flow, first downward, then outward through the nest of coils.

The supply of fuel is regulated to evaporate 90% to 95% of the water pumped through the coils. The excess water flushes scale and sludge from the coils and is carried over with the steam into the steam separator-221, where the water and sludge are removed before the steam flows into the trainline.

The excess water collects in the bottom of the steam separator. Water above the level of the return outlet flows out through a steam trap-223 and through the heat exchanger-213, where it gives up its heat to the incoming feed water. From the heat exchanger the return water flows through return water flow indicator-218 back to the water supply tank-232.

The motor converter-215 drives the blower-202, water pump-230 and fuel pump-209 at a constant speed. The water by-pass regulator-111 automatically controls steam generator output by regulating the amount of water fed to the coils. Before entering the coils, the water passes through servo-fuel control-10 which admits fuel to the spray nozzle in direct proportion to the amount of water entering the coils. The servo-fuel control also adjusts the damper-203 to admit the proper amount of air for efficient combustion of the fuel.

The trainline steam pressure is regulated by adjusting the handwheel on the water by-pass regulator-111. The length of train and the weather conditions determine the setting.

BEFORE STARTING

The valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle.

1. Make certain that the following valves are OPEN:

Atomizing Air Shutoff Valve-1
 Coil Shutoff Valve-3
 Return Water Outlet Valve-9
 Steam Admission Valve-11 to Trainline Pressure Gauge-224
 Steam Admission Valve-13 to By-Pass Regulator-111
 Three-Way Washout Valve-17
 Water By-Pass Regulator Shutoff Valve-19
 Water Supply Stop Valve-21

2. Be sure that the following valves are CLOSED:

Coil Blowdown Valve-2
 Layover Connection Shutoff Valve-6
 Manual Water By-Pass Valve-8
 Steam Admission Valve-10 to Radiation-217
 Washout Inlet Valves-14 and 16
 Water Pump Test Valve-18
 Water Drain Valves-20 and 22

3. See that both the overload reset button-106 and the stack switch-109 reset button are "in". The overload reset button is located inside the control panel on the magnetic overload relay.

TO FILL

1. Open the atomizing air shutoff valve-1 and fill-test valve-4, latch open the separator blowdown valve-12 to drain the steam separator. Close the separator blowdown valve when the separator is completely drained.
2. Close the main switch and turn the control switch-102 to FILL.
3. While the coils are filling see that spark-220 is available for ignition. Check ALL valves.
4. When water discharges from the fill-test valve-4 turn the control switch-102 to OFF and close the fill-test valve.

NOTE:

If the coils are empty it will take about five minutes to fill the steam generator with water.

TO START

CAUTION:

Do not start the steam generator unless the coils are filled.

1. Latch open the separator blowdown valve-12 and turn the control switch-102 to RUN (For easy starting, be sure the control switch has been OFF long enough for the motor to come to a full stop).
2. Close the separator blowdown valve when the generator steam pressure gauge-212 registers 50 lbs.
3. Open the separator blowdown valve several times for three to five second intervals during the first few minutes of operation.
4. Set the water by-pass regulator-111 to the required trainline pressure.
5. After the trainline is coupled open the stop and check valve-15.

NOTES:

1. Check the return water flow after the steam generator has settled down to a steady output. On 1600 lb. units the return water flow indicator-218 should cycle from 4 to 8 times a minute.
2. If the steam generator does not start or function properly, check all valves to see that they are open or closed as indicated in the operation chart.
3. The steam generator should come up to full operating pressure in one or two minutes; it may take 10 to 15 minutes to build up the required operating steam pressure in the trainline.

RUNNING ATTENTION

1. By closing the switch (above the main switch) in the engine room, a time relay is connected which will automatically cause the blowdown valve-12 to open for 3 seconds every 15 minutes. The driver can also by means of a push-button at the driver's place open the separator blowdown valve. An indicating light on the driver's panel will show each time the valve opens.
2. Turn the handle on the fuel filter-206 during stops.

TO SHUT DOWN THE STEAM GENERATOR

For short stops it is only necessary to close the stop and check valve-15. The fire will cycle and maintain operating pressure in the steam generator. For terminal stops, proceed as follows.

1. Close the stop and check valve-15.
2. Set the water by-pass regulator-111 to maximum output. When the generator steam pressure gauge-212 registers 200 lbs. turn the control switch-102 to OFF.

3. Open the coil blowdown valve-2. When the generator pressure drops to 75 lbs. close the valve.
4. Open the separator blowdown valve-12 and blow down the steam separator-221 with the remaining pressure. Close the separator blowdown valve.
5. Fill the coils with water.
6. Close the atomizing air shutoff valve-1 and open the main switch.

NOTE:

When starting, do not omit draining the steam separator, opening the fill-test valve, and again filling the steam generator with water. If the coils are already full, it will only take a moment for water to discharge from the fill-test valve.

FREEZING WEATHER PRECAUTIONS

The inlet valve-10 to the radiation-217 should be opened when operating during severe weather.

If a locomotive with a multiple installation does not have all of its steam generators in operation, open the coil blowdown valve-2 and the inlet valve-10 to the radiation on idle steam generators.

If a locomotive is left standing out of service, operate the steam generator or make a connection to the yard steam line. In extremely cold weather the water pump-230 and steam generator controls should be given additional protection against freezing.

If no steam at all is available, thoroughly drain the steam generator. Open the drain valves-20 and 22, the water pump test valve-18, the coil blowdown valve-2, the separator blowdown valve-12 and the coil shutoff valve-3. Break the pipe connections where necessary to completely drain the piping. Turn the water pump by hand to clear it of water, or blow it out with compressed air. Remove the cover of the water treatment or water strainer tank-234 and make sure it is drained.

TROUBLE SHOOTING

If one of the protective switches (magnetic overload relay, coil blowdown valve switch, stack switch high temperature contacts or low temperature contacts) operates to shut down the steam generator, the alarm horn will sound and the "boiler off" signal will flash on the driver's control panel.

Turn the control switch-102 to OFF and use the following instruction as a guide in locating the trouble.

Motor and Burner Shut Down During Operation

1. Circuit breaker "off": The alarm will not sound and the instrument lights will go out. The circuit breaker is located in the engine room. Check this breaker and check the control fuses in the steam generator control cabinet. A test lamp and fuse clips wired inside the control cabinet may be used to check the fuses.
2. Overload reset button-106 "out": The alarm horn will sound; the instrument lights will remain on. Turn the control switch-102 OFF; check for hot blower 202 or water pump-230 bearings and for poorly adjusted pulley belts. Check the setting of the belt tension adjuster. Push the overload reset button "in".
3. Stack switch-109 reset button "out": The high temperature contacts in the stack switch are open; the alarm horn will sound and the instrument lights will remain on. Turn the control switch-102 to OFF; open the separator blowdown valve-12 and drain the steam separator-221. Close the separator blowdown valve, push in the stack switch reset button, refill the coils with water, and then start the steam generator.
4. Coil blowdown valve-2 partially open: The alarm horn will sound the instrument lights will remain on. Be sure the locking pin on the coil blowdown valve handle is properly seated in the closed position.

Motor Starts But Burner Does Not

If the fire fails to light, the low temperature contacts on the stack switch-109 will not close, and after a 45 second time delay the outfire relay will open the circuit to shut down the steam generator. The alarm horn will sound and the instrument lights will remain on. Turn the control switch-102 OFF and check the following list for possible causes for the burner failure.

1. Ignition failure: Turn control switch to RUN - no spark visible through the peep hole glass, or spark is of low intensity.

Check the ignition fuses - use the test lamp and clips installed in the control cabinet for that purpose. Tighten loose cable connections and replace chafed or broken wire which may be breaking or grounding the circuit.
2. Low atomizing air pressure-201: The air switch-101 opens and breaks the circuit to the fuel solenoid valve-104, which then stops the flow of fuel to the sprayhead-105.

Be sure the air admission valve is fully open. Clean the strainer screen in the atomizing air line and drain the atomizing air pressure regulator-100. If the low atomizing air pressure persists, tighten the adjusting screw at the top of the air pressure regulator to increase the atomizing pressure.
3. Low fuel manifold pressure-208: Turn the handle on the suction line fuel filter-206 several times. A slight suction leak may cause the manifold pressure to build up slowly; put the control switch-102 on FILL to bleed the fuel line and bring the manifold pressure up to normal

4. Low fuel nozzle pressure-207: Lack of water causes the servo fuel control-108 to limit the supply of fuel entering the nozzle. (If the water supply is almost completely stopped, the cam plate may come down far enough to actuate the cutout switch on the servo and close the fuel solenoid valve-104).

Be sure that the pump, belts have proper tension, the water pump test valve-18 is closed, the cover on the water treatment or strainer tank-234 is tight, the three-way washout valve-17 is fully open, and that the drain valves-20 and 22 are tightly closed.

Open and close the water by pass regulator-111 adjusting handle several times to free the regulator from possible sediment. If the water pressure gauge-229 still registers low, close the water by-pass regulator shutoff valve-19. This closes the water by-pass line and permits all of the feed water to flow to the servo-fuel control 108; the steam generator will start at once if the by-pass regulator is causing the trouble. Set and manually regulate the trainline steam pressure by adjusting the manual water by-pass valve-8.

High feed water temperature or leaky water line connections may cause the water pump-230 to become air or vapor bound. Violent fluctuation of the water pressure gauge needle indicates this condition. Tighten leaky water line connections and bleed the line by opening the water pump test valve-18. Allow water to flow from this valve until no air or vapor bubbles are evident in the water.

Irregular Trainline Pressure

1. Burner cycles off and on: Insufficient water delivery causes the steam generator to run in superheat; the steam temperature limit control-110 operates to protect the coils against overheating. Check the water pump output as instructed in the preceding paragraphs.
2. Safety valves blow: Shut down the steam generator. Lower the trainline pressure setting on the adjusting handle of the water by-pass regulator-111 and start the steam generator again. If the safety valves-107 continue to pop, close the water by-pass regulator shutoff valve-19 and manually regulate the trainline steam pressure by opening and adjusting the manual water by-pass valve-8.

ITEMS TO REPORT

1. Water pressure greater than 450 pounds at any time.
2. Excessive stack temperature.
3. Fluctuation of the fuel manifold pressure.
4. Frequent cycling of the burner.
5. Water flow indicator not cycling.
6. Water by-pass regulator inoperative.
7. Faulty operation of the steam generator for any reason.

STEAM GENERATOR OPERATION CHART
TYPES OK-4616

- 100. Atomizing Air Pressure Regulator
- 101. Atomizing Air Switch
- 102. Control Switch
- 103. Fuel Pressure Regulator
- 104. Fuel Solenoid Valve
- 105. Fuel Spray Head
- 106. Overload Reset Button, Motor
- 107. Safety Valves
- 108. Servo-Fuel Control and Switch
- 109. Stack Switch
- 110. Steam Temperature Limit Control
- 111. Water By-Pass Regulator and Switch
- 112. Water Pressure Relief Valve
- 200. Atomizing Air Strainer
- 201. Atomizing Air Pressure Gauge
- 202. Blower
- 203. Damper
- 204. Fuel Filter (Fuel Pressure Line)
- 205. Fuel Filter (Servo Actuating Line)
- 206. Fuel Filter (Suction Line)
- 207. Fuel Nozzle Pressure Gauge
- 208. Fuel Pressure Gauge (At Fuel Pressure Regulator)
- 209. Fuel Pump
- 210. Fuel Strainer
- 211. Fuel Tank
- 212. Generator Steam Pressure Gauge
- 213. Heat Exchanger
- 214. Ignition Transformer
- 215. Motor Converter
- 216. Oil Filler Cap
- 217. Radiation
- 218. Return Water Flow Indicator
- 219. Return Water Strainer
- 220. Spark Plugs
- 221. Steam Separator
- 222. Steam Trap (Radiation)
- 223. Steam Trap (Return Water Line)
- 224. Trainline Steam Pressure Gauge
- 225. Treatment Injector Filter
- 226. Treatment Injector Gauge
- 227. Washout Solution Inlet
- 228. Washout Solution Outlet
- 229. Water Pressure Gauge
- 230. Water Pump
- 231. Water Strainer Manifold
- 232. Water Tank
- 233. Water Treatment Injector Pump
- 234. Water Treatment Tank (Strainer Tank Only
If Injector System Is Used)

VALVES

Valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle, normally closed valves are fitted with the standard round handle. These designations apply only to the OK series steam generators.

The following valves must be CLOSED during normal operation of the steam generator:

2. Coil Blowdown Valve and Switch
4. Fill-Test Valve
6. Layover Connection Shutoff Valve
8. Manual Water By-Pass Valve
10. Steam Admission Valve to Radiation (Open in cold weather)
12. Steam Separator Blowdown Valve
14. Washout Inlet Valve
16. Washout Inlet Valve
18. Water Pump Test Valve
20. Water Suction Line Drain Valve
22. Water Treatment Tank Drain Valve

The following valves must be OPEN during normal operation of the steam generator:

1. Atomizing Air Shutoff Valve
3. Coil Shutoff Valve
7. Remote Control Trainline Shutoff Valve
- 7a. Reset Lever
9. Return Water Outlet Valve
11. Steam Admission Valve to Trainline Pressure Gauge
13. Steam Admission Valve to Water By-Pass Regulator
15. Stop and Check Valve
17. Three-Way Washout Valve
19. Water By-Pass Regulator Shutoff Valve
21. Water Supply Stop Valve

STEAM GENERATOR TROUBLE SHOOTING CHART

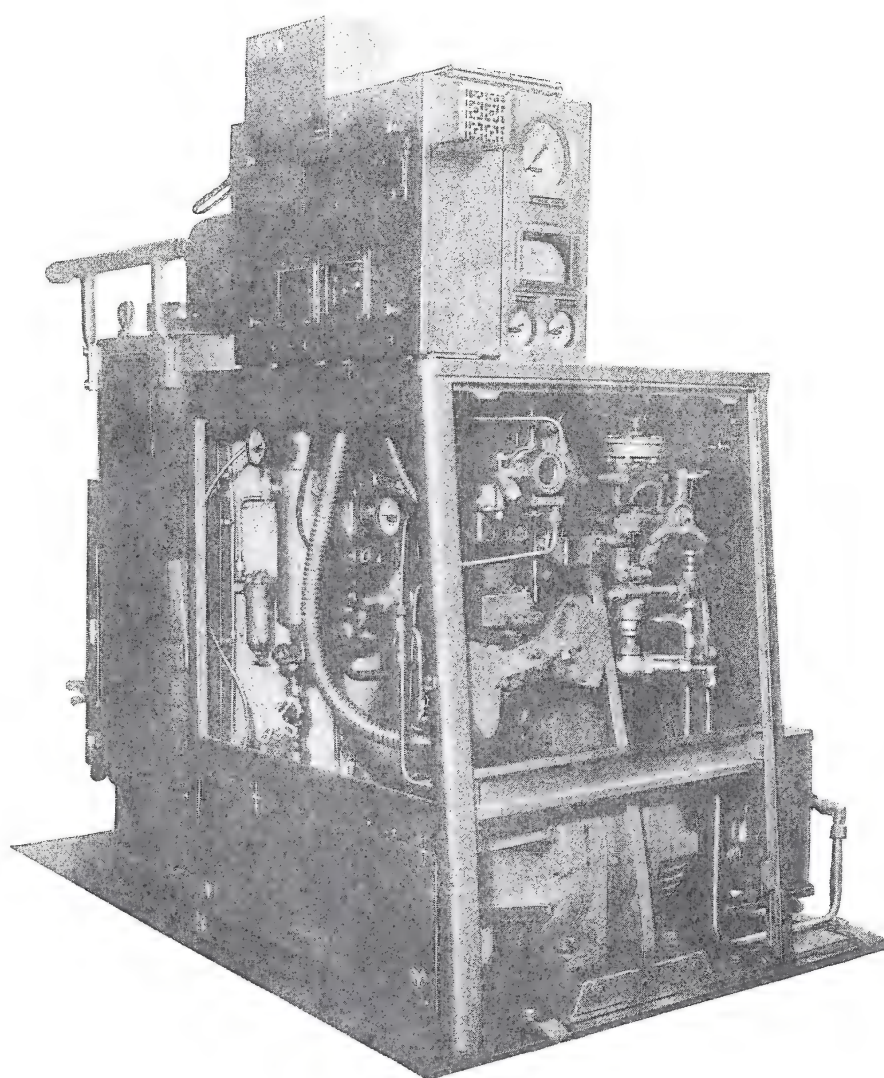
Symptoms	Cause of Trouble	Remedy
Panel lights do not light; horn does not sound (Control switch "OFF" Main boiler switch "ON")	Main battery switch "OPEN"	Close
	10 amp. control fuse (2) blown (boiler panel)	Test and replace
Motor does not run (control switch "FILL" horn sounds)	Stack switch tripped	Re-set
	Motor overload tripped	Re-set
	Coil blow down valve "OPEN"	Close
Motor runs no strong flow of water from water pump test valve	Water tank empty	Fill
	Valve on suction line closed (on line to treatment tank)	Open
	Drain valve on suction line or treatment tank open	Close
	Top of treatment tank not tight	Re-set and tighten
Water in storage tank too hot	Treatment tank strainer clogged	Clean
		Make sure steam heat valve to water tank is closed

STEAM GENERATOR TROUBLE SHOOTING CHART (CONT'D)

Symptoms	Cause of Trouble	Remedy
Motor runs, no spark at electrodes	Wires from electrodes to transformer broken or grounding	Repair
	Terminals loose on transformer	Tighten
	Gap between electrodes too wide	Reduce gap (should be 3/16")
<hr/>		
Motor runs, fire does not light "Run"	10 amp. ignition fuse (2 on boiler panel) blown	Test and replace
	Atomizing air valve closed	Open
	Motor not allowed to stop before turning switch to run	Turn "fill" briefly, then to "off". After motor has stopped and servo control is all the way down, turn to "Run".
	Electrodes not properly adjusted	Adjust. Report to maintenance.
	Nozzle not properly adjusted	Adjust. Report to maintenance.
<hr/>		
Generator shuts off, alarm horn sound	Stack switch tripped	Reset stack switch, refill coils, start steam generator and set water by-pass regulator at slightly lower pressure. Report to maintenance.

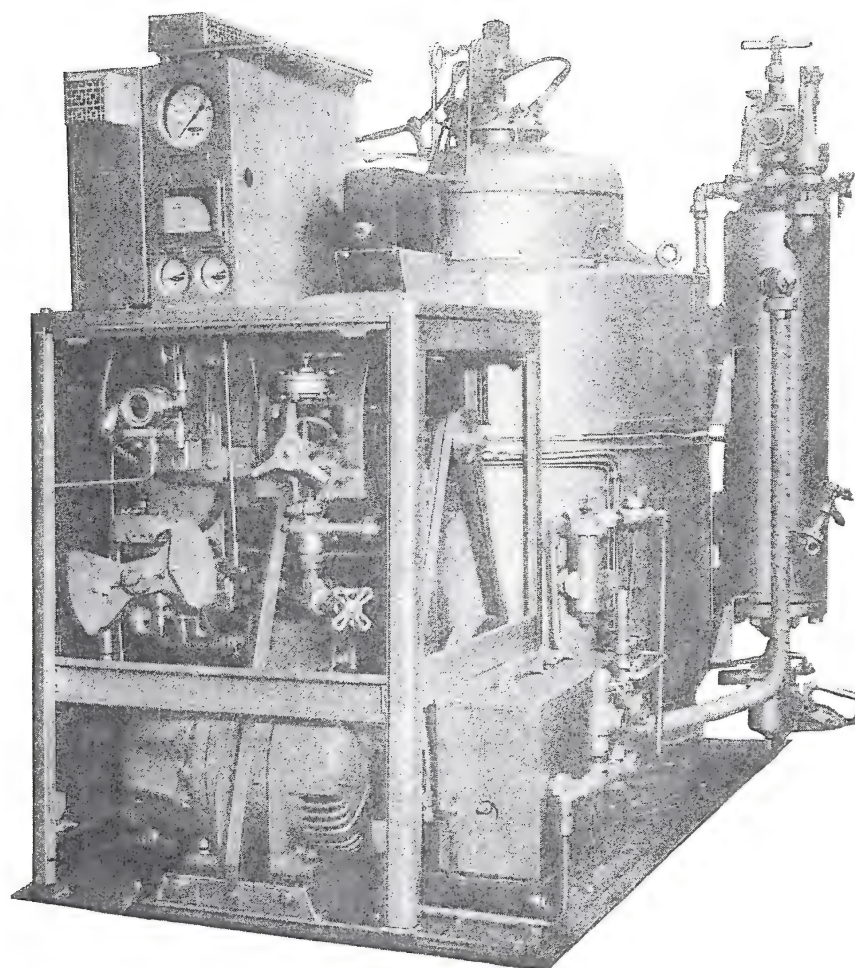
STEAM GENERATOR TROUBLE SHOOTING CHART (CONT'D)

Symptoms	Cause of Trouble	Remedy
Generator shuts off,	Motor overload relay trips, shutting down generator	Reset overload relay, refill coils and start steam generator. Report to maintenance.
Generator runs, dome gets hot	Lack of air, dirty coils	Set water by-pass regulator back 10 to 15 lbs. Report to maintenance.
Generator runs but no water returns through water flow indicator	Valve in return line from separator closed	Open
	Return water strainer clogged	Clean
	Steam too dry	Report to maintenance
Generator runs but trainline pressure cannot be controlled by water by-pass regulator	Steam admission valve closed	Open
	Water admission valve closed	Open
	Defective water by-pass regulator	Close water shutoff valve to water by-pass regulator, use manual by-pass valve to control pressure. Report to maintenance.



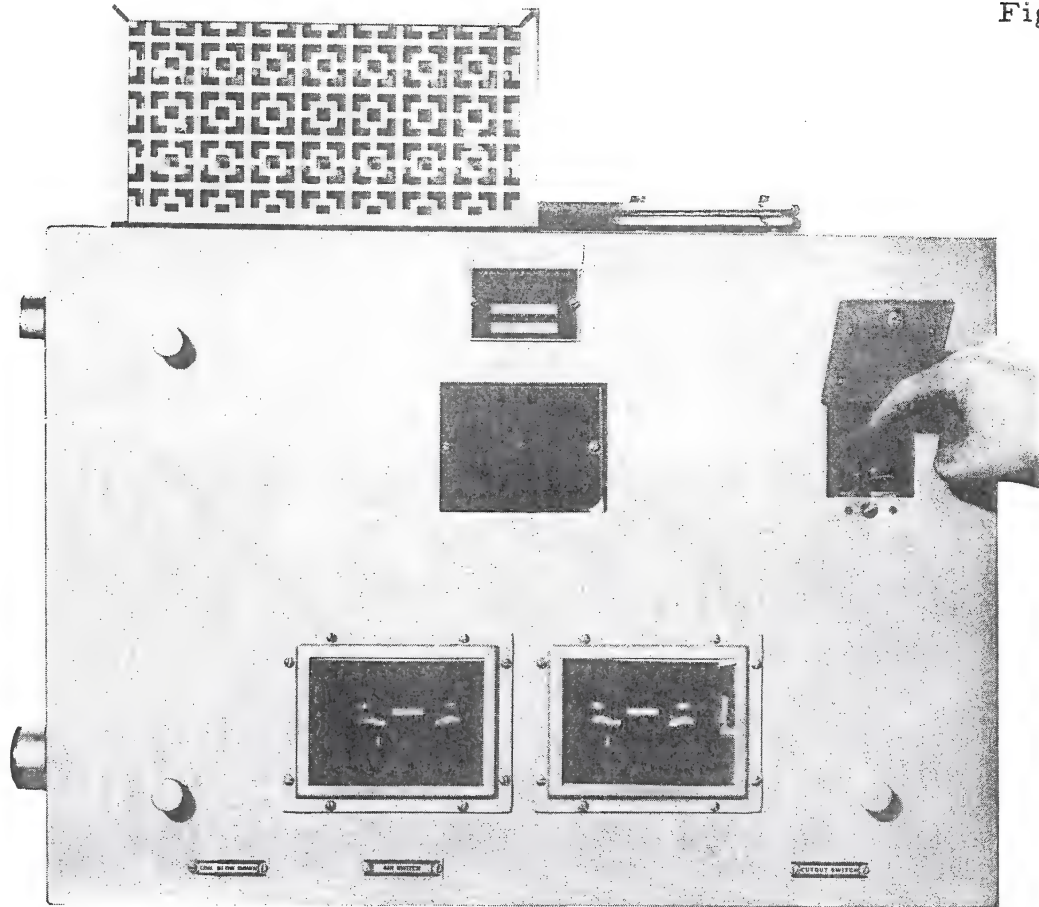
Steam Generator





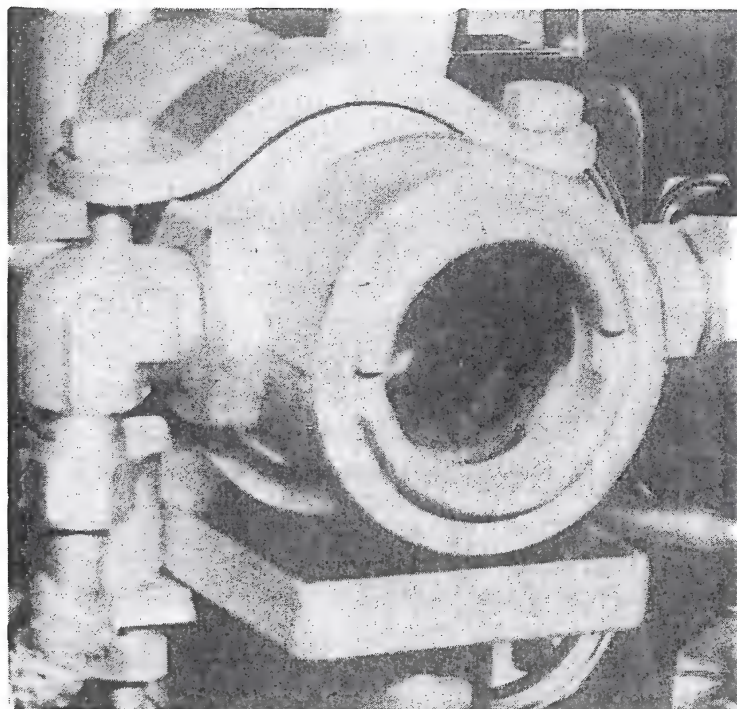
Steam Generator

Fig. 6-3

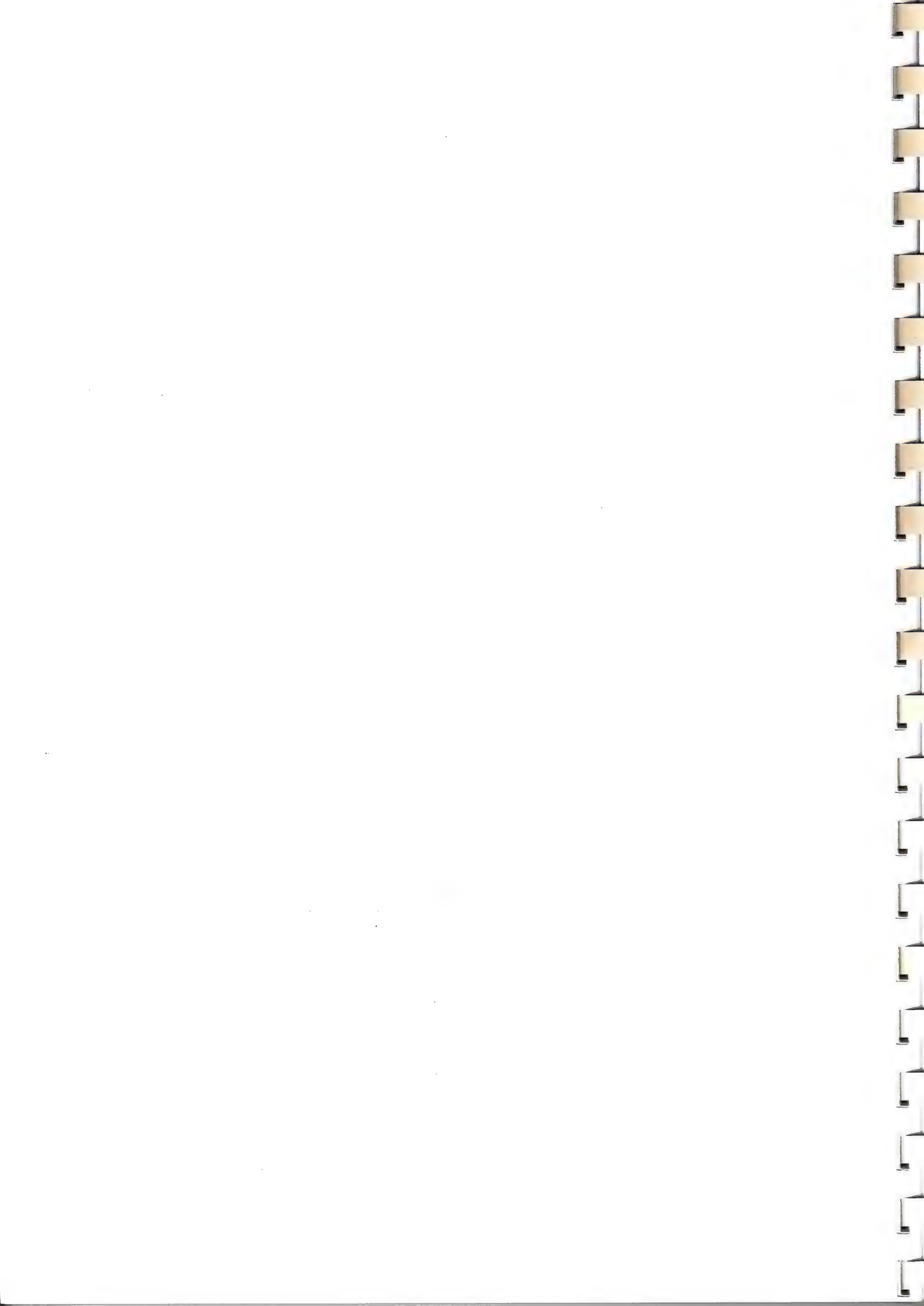


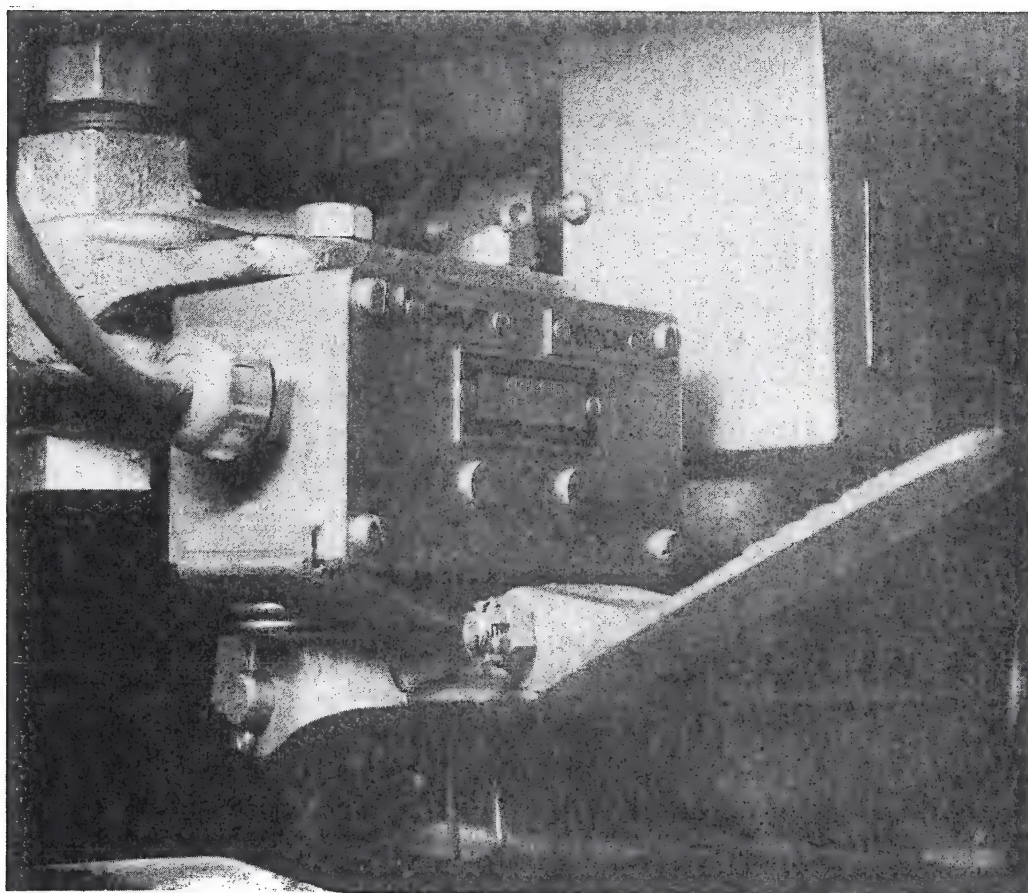
Control Panel

Fig. 6-4

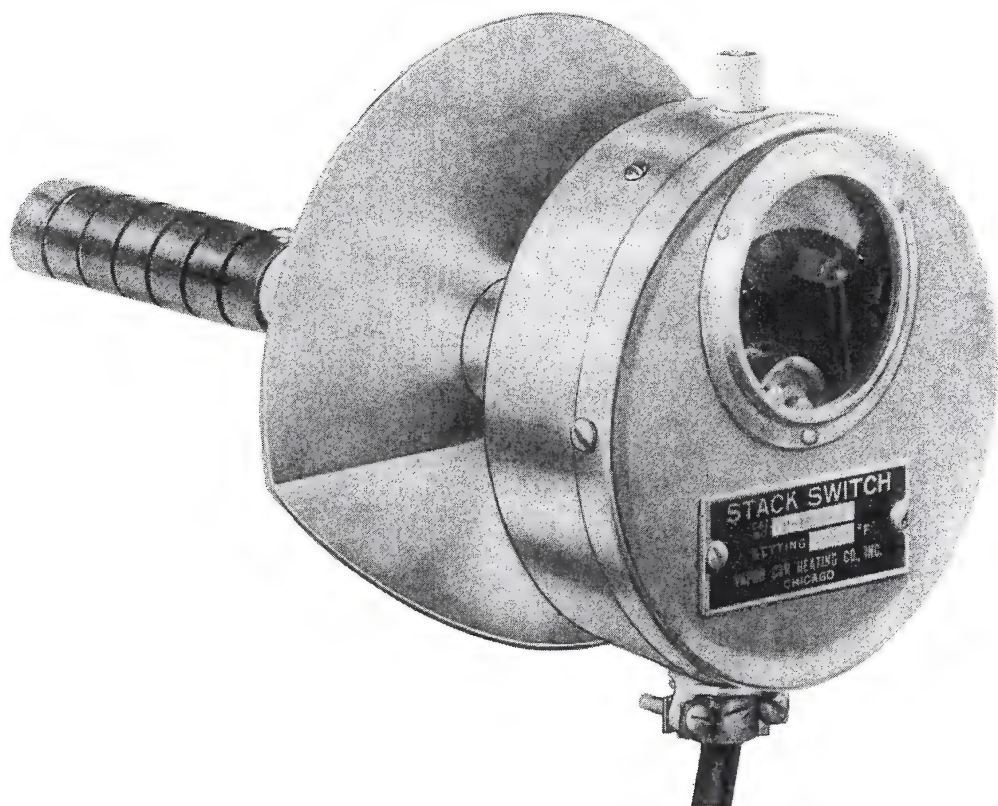


Return Water Flow Indicator

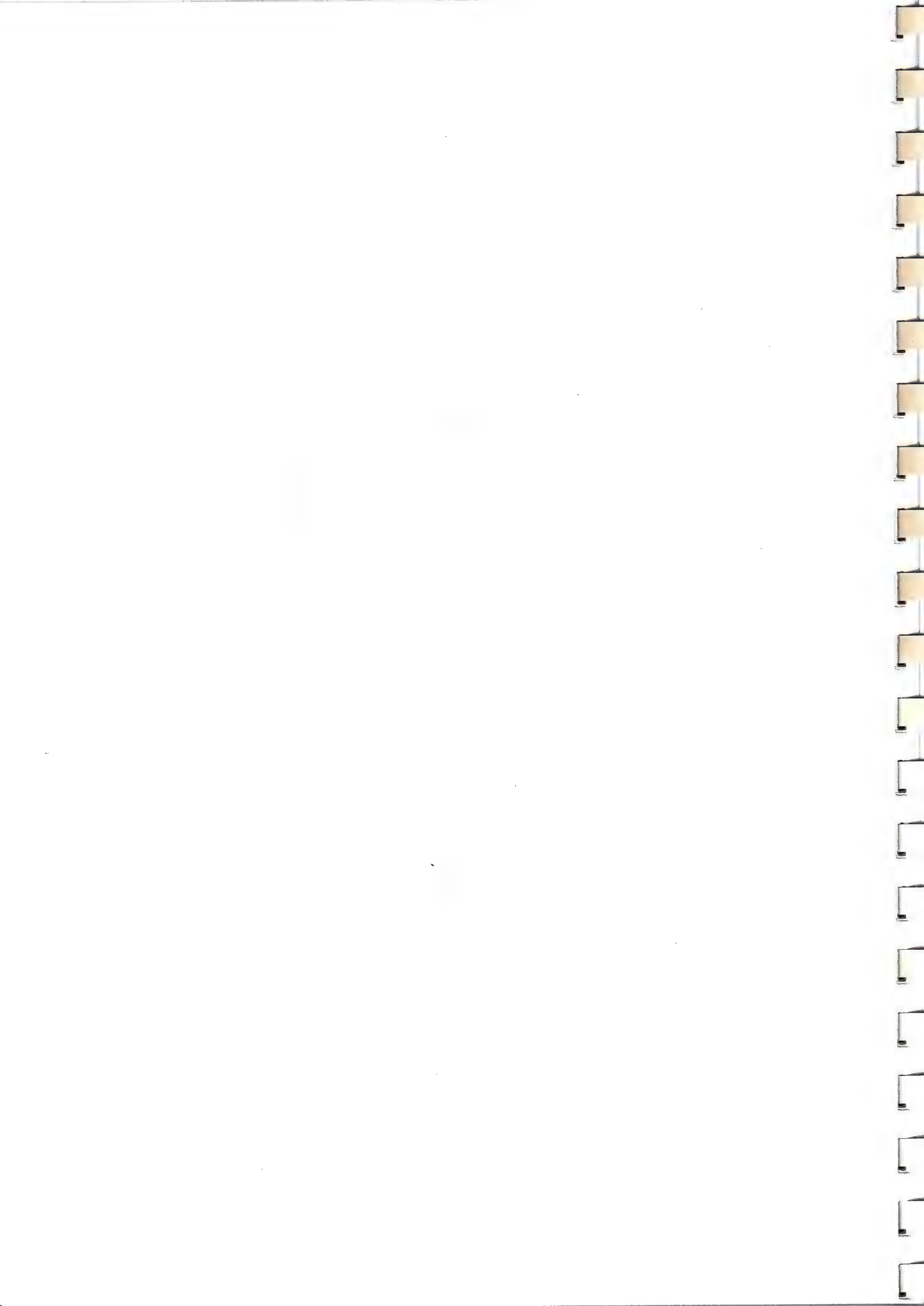


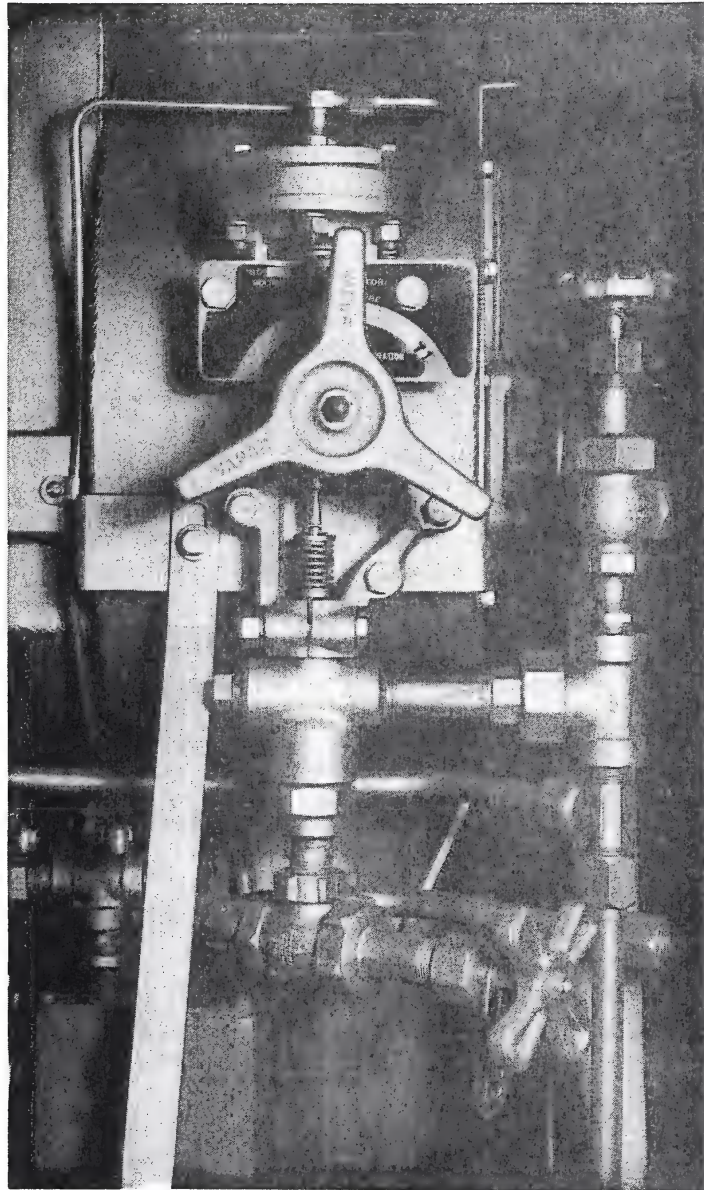


Coil Blowdown Valve



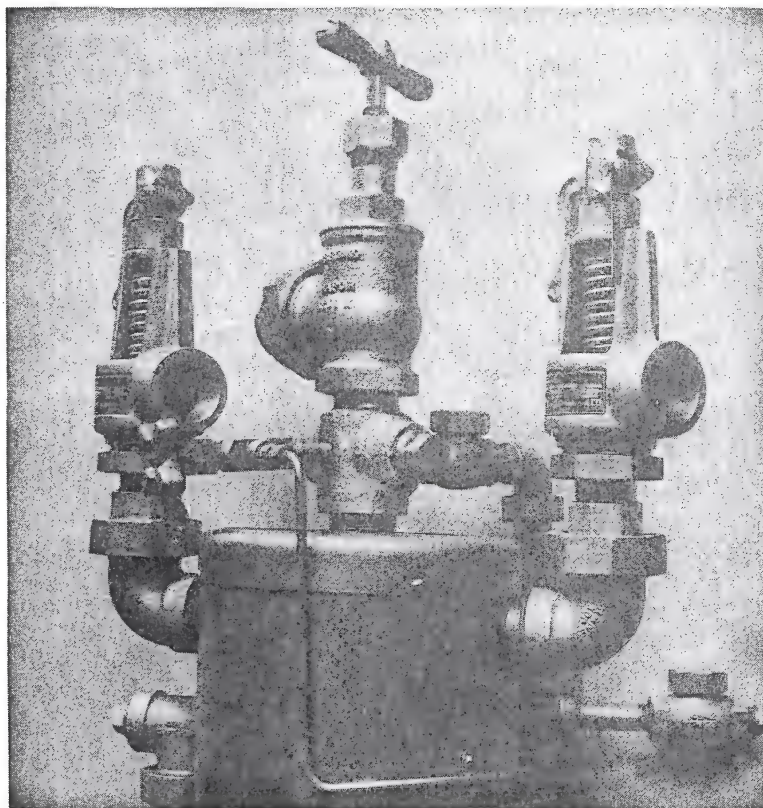
Stack Switch





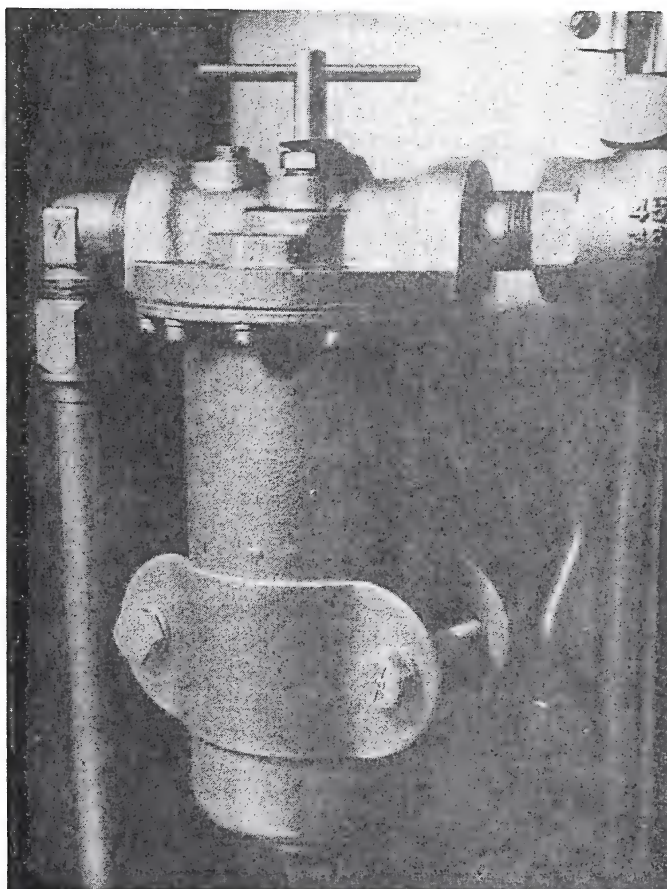
Water By-Pass Regulator

Fig. 6-8



Safety Valves and Stop and Check Valve

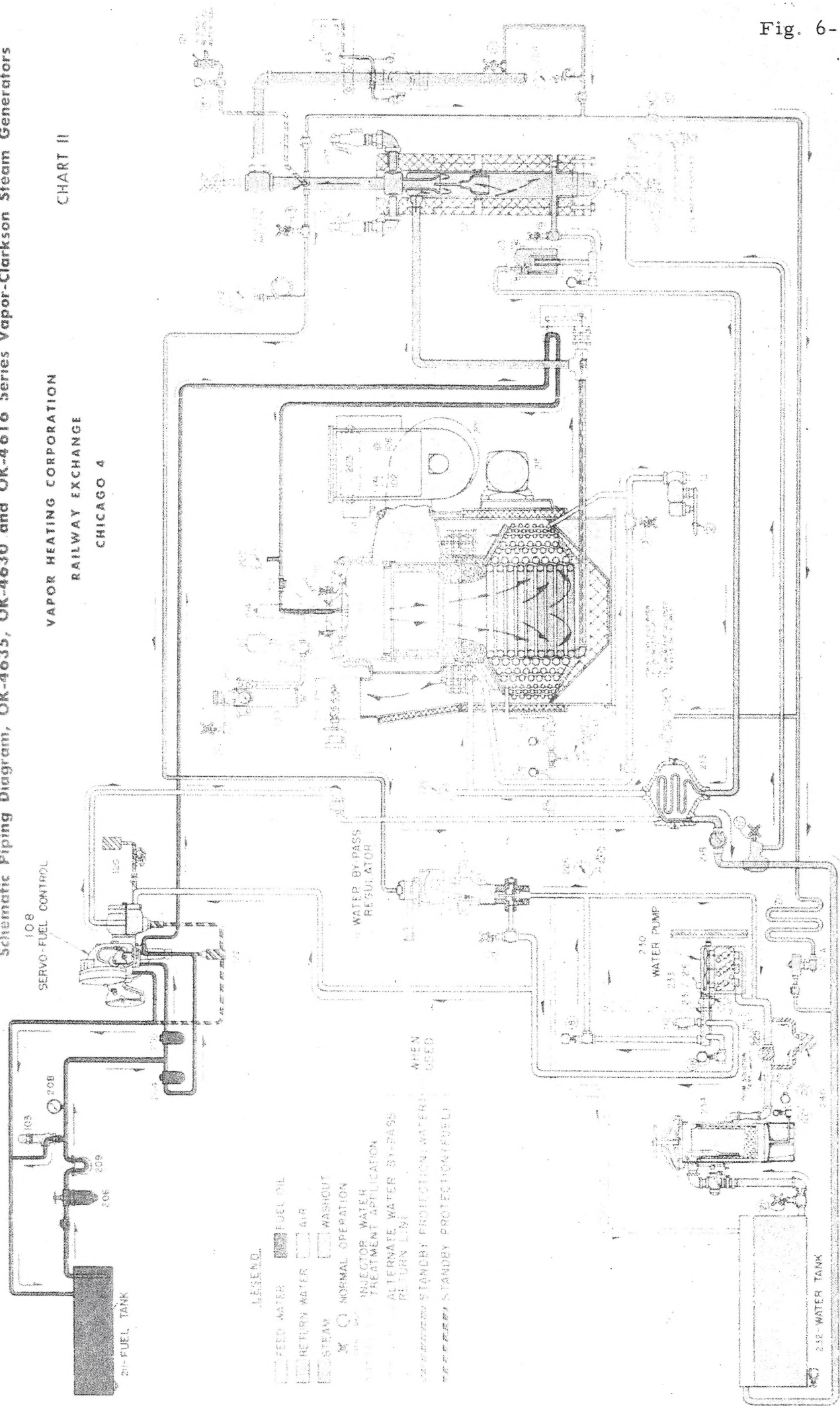
Fig. 6-9



Fuel Filter

Schematic Piping Diagram, OK-4635, OK-4630 and OK-4616 Series Vapor-Clarkson Steam Generators

CHART II
VAPOR HEATING CORPORATION
RAILWAY EXCHANGE
CHICAGO 4



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